

CONTRACT TR413

**REPLACEMENT OF TRAFFIC AND COMMUNICATIONS SYSTEM
FOR KALLANG-PAYA LEBAR EXPRESSWAY
AND MARINA COASTAL EXPRESSWAY**

TECHNICAL SPECIFICATION

ATTACHMENT A

CONTRACT TR413

TS-ATT A-i

TECHNICAL SPECIFICATION

TRAFFIC AND PLANT MANAGEMENT SYSTEM

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Traffic And Plant Management System

1 General

- 1.1 The Traffic and Plant Management System (TPMS) shall comprise the following systems and equipment in Kallang Paya Lebar Expressway and Marina Coastal Expressway (KPE/MCE):
- (a) Traffic Control and Surveillance System (TCSS)
 - (i) Automatic Incident Detection (AID) System;
 - (ii) Closed Circuit Television (CCTV) Surveillance System;
 - (iii) Web Cameras (Webcam); and
 - (iv) Traffic Barrier System.
 - (b) Plant Monitoring and Control System (PMCS)
 - (i) Remote Input/outputs (RIO); and
 - (ii) Profibus Input and Output Slave (PIOS).
 - (c) Video Wall System.
- 1.2 There are six (6) Ventilation Buildings (VB) located along KPE namely, VBA, VBB, VBC, VBD, VBE and VBF. There are two (2) VBs located along MCE namely, VB1 and VB2. The term VBs used in this Technical Specification (TS) refers to all VBs located in KPE and MCE.
- 1.3 The KPE/MCE main Operations Control Centre (OCC) is at Ventilation Building 1 (VB1) and Standby OCC (SOCC) is at Ventilation Building D (VBD). The term OCCs in the TS shall refer to both the main OCC and the standby OCC, unless otherwise specified.
- 1.4 The Integrated Traffic and Plant Management (ITPMS) provided by others in the OCC and SOCC will monitor and control all the traffic and plant equipment in the KPE/MCE tunnels, slip roads, approach roads, depressed roads and on open expressway. The term ITPMS used in this TS ATT A refers to KPE-MCE ITPMS 2.0 provided under Contract TR811, unless otherwise specified. The KPE-MCE ITPMS 1.0 is provided under Contract TR342 i.e. one of the Employer's appointed contractors.

2 Scope of works

- 2.1 The scope of this Contract covers the design, supply, delivery, installation, implementation, migration, testing, commissioning, decommissioning, maintenance during Defects Liability Period (DLP), documentation, training and any other necessary works required for the completion of the project.
- 2.2 The Contractor shall design, supply, deliver to site, install, test and commission the TPMS including the provision of equipment, servers, processors, controllers, workstations, laptops, equipment, enclosures, cabinets/racks, cables, cable supports, mounting accessories, power distribution, network switches, lightning protection devices and all necessary devices and accessories to enable the successful commissioning of TPMS.
- 2.3 The Contractor shall supply, modify and install all the necessary hardware and software in the VBs and tunnel niches to ensure that all TPMS equipment can be monitored and controlled from KPE/MCE OCCs. The works at the VBs and tunnel niches shall also include power provision to the TPMS equipment and all necessary electrical works.
- 2.4 The Contractor shall perform configuration and programming works on the existing Programmable Logic Controllers (PLC) at the VBs and on the existing and new Remote Input/outputs (RIO)/ Network RIO in the KPE/MCE tunnels, to include all the I/O points for monitoring and control for all existing and new equipment in KPE/MCE.
- 2.5 The Contractor shall refer to **TS Appendix A-1** for the diagram of AID architecture, **TS Appendix A-2** for the diagram of CCTV and Webcam Architecture and **TS Appendix A-3** for the diagram of PMCS architecture.
- 2.6 The Contractor shall carry out site survey during the design phase to verify the existing quantity, size and location of the existing TPMS equipment. The Contractor shall refer to **TS Appendix A-4** for the location and quantity of TCSS and PMCS equipment.
- 2.7 The Contractor shall ensure that all TPMS installed at the KPE/MCE tunnels ceiling or soffit shall conform to the vertical traffic headroom clearance of 5.1 metres. The Contractor shall conduct site survey to determine the vertical traffic headroom clearance.
- 2.8 The Contractor shall provide Geographical Information System (GIS) coordinates (in Survey21 coordinate system) and Global Positioning System (GPS) coordinate's location with location descriptions for TPMS

equipment in the tunnels, at-grade and road furniture in KPE/MCE, to ITPMS and the SO.

- 2.9 The Contractor shall appoint a registered surveyor to provide the exact position, GIS co-ordinates (in Survey21 coordinate system) and GPS co-ordinates of all field equipment locations of the TPMS. This shall be included in the submission for the SO's acceptance.
- 2.10 The Contractor shall provide and submit numbering for all equipment of the TPMS and coordinate with ITPMS contractor on the equipment numbering to ensure TPMS equipment in KPE/MCE to be uniquely identified. The Contractor shall propose the equipment naming convention and its numbering principles, before and after migration. The Contractor shall submit document and drawing submissions with the numbering assigned to TPMS equipment before and after migration.
- 2.11 The Contractor shall also design, supply and install a dedicated Network Management System (NMS) to monitor the TPMS network. All network alarms and faults from the TPMS network and equipment shall be sent to ITPMS via NMS.
- 2.12 The Contractor shall plan, liaise, interface and coordinate with all relevant interfacing contractors, to determine the interface requirements including testing and commissioning with ITPMS, Unified Maintenance Hub (UMH), Expressway Monitoring and Advisory System (EMAS), Singapore Civil Defence Force (SCDF), Singapore Police Force (SPF), Employer's appointed contractors for the Intelligent Transport Systems Centre (ITSC) CCTV system, TR342, TR353A, TR353B, TR406, etc. The details of the system interfaces are specified in **TS Attachment E**.
- 2.13 The Contractor shall coordinate and provide all necessary information to Employer's appointed contractors for configuration of existing network devices and equipment. All information provided by the Contractor to Employer's appointed contractors shall be properly documented.
- 2.14 The Contractor shall provide and supply all materials including labour, tools, equipment, storage, supervision, approved permits and certificates from relevant authorities, unloading at site, installation, interface, testing and commissioning of the works necessary to complete the project in a proper and professional manner acceptable to SO and all other authorities having jurisdiction over the works.
- 2.15 All coordination works and interfacing works with other authorities and agencies shall be included within this Contract scope.

- 2.16 The Contractor shall ensure the full compatibility for the interfacing equipment. Any hardware, software, upgrades and changes required to ensure the full compatibility of the interface shall be provided.
- 2.17 The Contractor shall be responsible for decommissioning, removing and perform a proper disposal of the replaced equipment is under this Contract.

3 Design Requirements

- 3.1 The design of the TPMS shall include the following minimum requirements.
 - (a) All servers and workstations shall be provided with at least 100% spare for hard disk, Random Access Memory (RAM) and CPU capacity;
 - (b) All servers and workstations shall follow Redundant Array of Independent Disks (RAID) configuration:
 - (i) Workstations: RAID 1; and
 - (ii) Servers: RAID 5.
 - (c) All network switches shall be provided with minimum 30% spare ports. All switches installed in tunnels and outdoors shall be of industrial grade.
- 3.2 Network Requirements
 - 3.2.1 The software, firmware and licenses for network devices shall be provided and shall be supported by the principal manufacturer throughout Contract period. Upon principal manufacturer announced End-of-Support for firmware and/or licenses, the Contractor shall recommend and provide principal supported firmware and/or licenses for the remainder of the Contract. There shall not be any change in service level and scope of maintenance for this Contract due to change in network firmware and/or licenses unless given acceptance by the Superintending Officer.
 - 3.2.2 The proposed network infrastructure shall not have any network visibility on the internet or any wireless capabilities.
 - 3.2.3 The Contractor shall provide end-to-end encryption across all channels.
- 3.3 System Master Time Clock

- 3.3.1 TPMS shall have time synchronisation with the new Network Time Protocol (NTP) clock source from Communications System provided under this Contract.
- (a) From the clock source, the Contractor shall provide time synchronisation for the TPMS. The frequency of time synchronisation shall be determined during the design interface.
 - (b) All the servers, workstations and various sub-systems provided under this Contract shall be synchronised with the NTP master clock to within +/-1 second accuracy.
- 3.4 Selection of Technology and Equipment
- 3.4.1 The Contractor shall take into consideration of the system design and selection of system components to ensure good performance, reliability, compatibility, durability and future expansion.
- 3.4.2 The system shall be designed and manufactured in accordance with the latest techniques and technology with proven track record of performance and reliability.
- 3.4.3 The system provided shall conform to international standards, local standards and open standards to ensure future engineering support services are available from more than one supplier.
- 3.4.4 All cameras shall comply with specification of Open Network Video Interface Forum (ONVIF) for inter-operability between IP-based network video devices.
- 3.4.5 All equipment proposed shall as far as possible be of proven standard products and the system proposed shall be of proven design based on the experience of the Contractor in the traffic control and monitoring of road networks and tunnels. The Contractor shall submit during design submission a list of detailed description of all the hardware and software to be provided. The details shall include the name of the manufacturer, model, year of manufacture, data sheets catalogue, product roadmap and relevant specifications.
- 3.4.6 All equipment installed shall have been proven to work and function in a road tunnel environment similar to KPE/MCE, subject to the SO's acceptance.
- 3.4.7 The server shall be a microprocessor-based computer unit complete with central processing units, peripherals, communication interfaces, hardware, software, internal real-time clock and memory.

- 3.4.8 The network operating system shall support Transmission Control Protocol/Internet Protocol (TCP/IP).
- 3.4.9 Energy efficient computer system including workstations, laptops, servers and monitors which meet the Energy Star requirement and Electronic Product Environmental Assessment Tool (EPEAT) standards shall be used.
- 3.5 System Expandability
 - 3.5.1 Provision shall be made in the design so that any hardware, software or data changes required to bring future extensions on-line shall be accomplished without major disruptions to the operational system. The system shall be of modular construction. The system shall be capable of future expansion through the simple addition of modules without changing the previously installed equipment or adversely affecting the operational system.
- 3.6 System Capacity
 - 3.6.1 The system shall be designed with a capability for future expansion. The Contractor shall cater for an increase of a minimum of 30% capacity of field equipment.
- 3.7 Operation and Maintenance
 - 3.7.1 The Contractor shall provide and supply all material and labour for the maintenance of the TPMS during the Defects Liability Period (DLP).
 - 3.7.2 The system shall be designed for operational requirement and ease of maintenance. The system and equipment shall be designed to carry out self-diagnostic functions.
 - 3.7.3 The Contractor shall provide configuration tools to facilitate the future upgrade, addition, modification and reconfiguration works.
 - 3.7.4 All the components of the TPMS shall be of module-type to ease the maintenance of the system.
 - 3.7.5 Faults and monitoring status from the TPMS equipment shall be sent to KPE-MCE ITPMS 1.0. The Contractor shall migrate these interfaces to KPE-MCE ITPMS 2.0 at a later stage. Refer to the table below for the TPMS that require monitoring and control by KPE-MCE ITPMS 1.0 and KPE-MCE ITPMS 2.0.

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TPMS	KPE-MCE ITPMS 1.0	KPE-MCE ITPMS 2.0
Automatic Incident Detection (AID) System		√
Closed Circuit Television (CCTV) Surveillance System		√
Web Cameras (Webcam)		√
Traffic Barrier System	√	√
Plant Monitoring and Control System (PMCS)	√	√
Video Wall System		√

3.8 Environmental Adaptability

3.8.1 All hardware shall be capable of operating normally under ranges of temperature and humidity prevalent in the environment in which it is located. The Contractor shall provide these details for acceptance by the SO.

3.8.2 All equipment and systems shall be fully suitable for operation in the local Singapore environmental and tunnel conditions.

3.8.3 All field equipment shall be designed to operate under the conditions of vibration generated by vehicular traffic.

3.8.4 The Contractor shall design and supply equipment to meet the following environmental conditions depending on the locations.

- (a) OCC and SOCC (air conditioning)
 - (i) Temperature: 15-35°C
 - (ii) Humidity: 90% RH, no condensation
- (b) Tunnel
 - (i) Temperature: up to 55°C

3.9 Installation

3.9.1 The Contractor shall submit installation plans and procedures two (2) months before commencement of installation to the SO for acceptance.

- 3.9.2 The Contractor shall design, supply and deliver to site the new cabinets/racks for TPMS in KPE/MCE ventilation buildings. The servers, communication equipment and other peripherals for TPMS shall be rack mounted and housed in the cabinets/racks. Any workstation installed in the rack shall be foldable and rack mounted type.
- 3.9.3 The Contractor shall remove and perform proper disposal of existing three (3) unused racks and unused cables in Computer room at VBD to cater space for the new cabinets/racks for TPMS.
- 3.9.4 All equipment shall be installed to allow easy access, removal and replacement for system maintenance.
- 3.9.5 Internal trunking, cable trays and hardware provision shall maintain a 30% spare space factor to provide for future expansion.
- 3.9.6 The Contractor shall provide secondary supports for all overhanging tunnel TPMS equipment. The supports provided shall be able to support the weight of the equipment in the event of the primary equipment support failure.
- 3.10 Power Supply and Distribution Requirements
 - 3.10.1 All electrical installations shall comply with the latest SS 638 and Energy Market Authority (EMA) Regulations. All electrical power designs and associated drawings shall be endorsed by qualified Licensed Electrical Worker (LEW) of appropriate grade.
 - 3.10.2 The Contractor shall provide power supply and all associated peripherals requirements of the proposed TPMS equipment.
 - 3.10.3 All electrical wiring shall comply with the latest cable colour code as per EMA requirements.
 - 3.10.4 All electrical power designs, calculations and associated drawings shall be endorsed by qualified Licensed Electrical Worker (LEW) of appropriate grade.
 - 3.10.5 All electrical equipment supplied shall be provided with the necessary protection against lightning, voltage surges, line noise and electromagnetic interference.
 - 3.10.6 All equipment shall be properly protected by Miniature Circuit Breakers (MCB).

- 3.10.7 The Contractor shall provide dedicated Uninterruptible Power Supply (UPS) to support the servers for TPMS for at least 30 minutes in the event of failure of the incoming supply.
- 3.10.8 The Contractor shall liaise with Employer's appointed contractors on power loading requirements for power supply to TPMS equipment, on the location and number of MCBs. The Contractor shall design to connect the TPMS's equipment to MCB. Transient voltage protection shall be provided for all cabinets/racks for TPMS in the ventilation buildings.
- 3.11 Interface and coordination with ITPMS and EMAS contractors
- 3.11.1 The Contractor shall provide workstations for CCTV surveillance system interface and coordinate with ITPMS and EMAS contractors. The minimum quantity of the workstations is indicated below.
- (a) OCC (six (6) workstations with a minimum 24-inch LED bezel-less monitor each, mouse each and CCTV keyboard each) at KPE/MCE VB1;
 - (b) SOCC (six (6) workstations with a minimum 24-inch LED bezel-less monitor each, mouse each and CCTV keyboard each) at KPE/MCE VBD;
 - (c) Conference room (two (2) workstations with a minimum 24-inch bezel-less LED monitor each, mouse each and CCTV keyboard each) at KPE/MCE VB1; and
 - (d) Computer room (two (2) workstations with a minimum 24-inch LED bezel-less monitor each, mouse each and CCTV keyboard each) at ITSC.
- 3.11.2 All interface details, between ITPMS contractor and the Contractor, shall be discussed and commonly agreed upon by the Contractor and ITPMS contractor subject to the acceptance of the SO. All available traffic information shall be able to be transmitted to ITPMS. The information include, but not limited to the following:
- (a) Average Speed (km/hr);
 - (b) Volume per lane;
 - (c) Lane occupancy;
 - (d) Average vehicle length;
 - (e) Average delay (actual average time that each vehicle is within a detection zone); and
 - (f) Vehicle class type and its flow (vehicles/hr) per lane.

- 3.11.3 Time for transferring the above traffic information shall not exceed one (1) second and the updated frequency shall also be configurable.

4 Hardware And Software Requirements

4.1 Servers

- (a) The hardware shall include, but not limited to the following:
 - (i) The servers shall incorporate fully programmable digital computers capable of real-time processing and offer multi-tasking, multi-user operation and workstation. Servers shall be identical and servers shall maintain communication with ITPMS. The servers shall receive the equipment status and field data.
 - (ii) Each server shall be a complete suite incorporating processor, memory, bulk data storage facilities, input/output processing facilities, data communications adaptors and power supplies.
- (b) The servers shall be of proven high quality and reliable off-the-shelf RISC system suitable for use in high-speed system processing environment with full hot-standby redundancy.
- (c) The servers shall support a wide range of interface, both hardwire and optic fibre, with data rate of up to 1Gbps. Redundant output ports shall be provided to maximise the available data paths communicating with the computers, peripherals and other systems. The Contractor shall provide necessary ports for interface plus minimum 30% spare ports fully wired, terminated, initialised and ready for use. A minimum of 100% spare traffic capacity shall be provided.
- (d) A full technical specification of the proposed server type and model shall be submitted to the SO for acceptance.

4.2 Changeover and Update Facility

- (a) The system shall incorporate an automatic changeover mechanism, inter-computer link adaptor and other auxiliaries to provide a smooth changeover of on-line server. The changeover mechanism shall be provided with a manual override facility.
- (b) The changeover mechanism shall include a "watchdog" facility for monitoring the integrity and operation of each server.

- (c) Failure of the on-line server shall cause the changeover mechanism to automatically cause the hot-standby server to become on-line.
- (d) Operational status of servers and the peripheral equipment for TPMS shall send to ITPMS.
- (e) The changeover process shall not result in any loss or corruption of any data.
- (f) The Contractor shall submit to the SO for acceptance on the details of the fault shut down sequence during complete system failure, including power failure, in the design submission.

4.3 Monitors

- (a) The Contractor shall provide minimum 24-inch LED bezel-less monitor with a resolution of no less than 1920x1080 pixels.
- (b) The refresh rate shall be such that flicker and annoying display aberrations are not perceivable to the OCC operator.
- (c) LED monitors installed in the cabinets/racks shall be of the foldable type.

4.4 Hard Drive Unit

- (a) The disk unit shall have a built-in control circuit to enable a smooth power-down cycle in the event of power supply disturbances to ensure that neither the disk mechanism nor the data files contained therein are damaged.

4.5 Workstations and User Interface

- (a) The workstation shall be of proven high quality and reliable off-the-shelf system designed for multi-tasking and graphics intensive applications, which require large processing power.
- (b) Each workstation shall also support multiple video input channel (minimum of 4 nos.) for CCTV camera picture display.
- (c) The workstation shall be able to support a wide range of interface with data rate of up to 1Gbps. Redundant output ports shall be provided to maximise the available data paths communicating with the computer, peripherals and other systems. In addition, it shall also provide external video and audio capabilities.
- (d) Each workstation set shall comprise:
A high-speed processing unit including power supply and all ancillaries with the following minimum requirements:

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- (i) Intel® Core™ i7 or higher;
- (ii) A minimum of 16 GB Random Access Memory or higher;
- (iii) Hard disk drive of 1 TB or higher;
- (iv) Keyboard and mouse;
- (v) On board sound;
- (vi) LED bezel-less monitor with a minimum 24-inch diagonal screen measurement and 1080p resolution of no less than 1920 x 1080 pixels;
- (vii) Graphic card;
- (viii) USB ports, HDMI ports;
- (ix) All requisite software and licences as appropriate;
- (x) Latest anti-virus software;
- (xi) Each set shall be capable of displaying visually the entire range of information, including status, alarms, etc.;
- (xii) The actual functions available at any particular workstation shall be defined by a user-configurable parameter table specific to that workstation. In addition, workstation access shall be password controlled with available functions assignable to a password level; and
- (xiii) Microsoft Windows Professional Operating System;

4.6 Maintenance Laptop

- 4.6.1 The Contractor shall supply one (1) maintenance laptop for maintenance, testing and commissioning of the TPMS for KPE/MCE.
- 4.6.2 The maintenance laptop must be protected by the latest virus protection software. The software must be proven commercial off the shelf products. The software shall be updated on a regular basis, at least every three (3) months till the end of Defects Liability Period (DLP). Virus definition file shall be updated as and when new update is available or minimum once a month.
- 4.6.3 The maintenance laptop shall be provided to satisfy the maintenance requirements of the system. As a minimum, the laptop shall be provided with the following:
 - (a) Intel® Core™ i7 or higher;
 - (b) A minimum of 16 GB RAM or higher;
 - (c) Hard disk drive of 1 TB or higher;

- (d) On board sound;
- (e) Graphic Card;
- (f) USB ports, HDMI ports;
- (g) Mouse;
- (h) Latest version of Microsoft Office Professional Edition;
- (i) Latest version of Microsoft Professional Operating System;
- (j) Latest anti-virus software;
- (k) Software diagnosis tools for fault finding;
- (l) Application software to monitor and control the TPMS equipment;
- (m) Application software for configuration/programming of TPMS; and
- (n) All requisite software and licences as appropriate.

4.6.4 The maintenance laptop shall be sufficiently sized to incorporate, as a minimum but not limited to the following functionalities:

- (a) Remote monitoring and control of TPMS;
- (b) Software deployment for TPMS; and
- (c) Perform diagnostic tests on TPMS.

4.6.5 The maintenance laptop shall be provided with the necessary connection cables for the interface with TPMS.

4.7 Flexibility of Choice for System Hardware

- (a) The Contractor shall ensure that the system hardware to be supplied shall be of the latest model. The Contractor shall, at the end of the design period or later depending on the delivery time of equipment, present the latest type and specification of the equipment for acceptance by the Superintending Officer (SO) and if accepted shall procure and install them in lieu of those earlier offered.
- (b) The Contractor shall also produce supporting information indicating the guaranteed production and maintenance life cycle, including provision of spares beyond the installation date.

4.8 Systems and Application Software

4.8.1 Modular software design shall be adopted to permit easy addition of further software modules to meet future expansion requirements. The

Contractor shall use standard versions of programming languages and compiler to allow the software applications to be ported easily to other hardware platforms.

4.8.2 All systems and application software shall be of the latest proven versions.

4.9 Hardware Diagnosis

- (a) Off-line and on-line diagnosis routines for disk drives, CPUs, memories and all other peripherals shall be provided together with detailed operating instructions.
- (b) The Contractor shall include in full details on the standard debugging programs.
- (c) Modular software design shall be adopted to permit easy addition of further software modules to meet future expansion requirements. The Contractor shall use standard versions of programming languages and compiler to allow the software applications to be ported easily to other hardware platforms.

4.10 Database Software Requirements

- (a) The Contractor shall propose database that is compatible with existing application architecture, robust and stable enough to satisfy the system's functional and performance requirements.
- (b) The Contractor shall be responsible for installation of the database software inclusive of all the necessary patches.
- (c) The proposed database version shall be the latest stable version at the time of implementation.
- (d) The Contractor shall ensure that the database support is provided directly by the Database Product Principal.
- (e) The proposed database version must remain supported throughout the Contract period. Otherwise, the Contractor shall be responsible for upgrading the database to a supported version. The support shall refer to the main support provided by the database product principal and not the extended support by third parties.
- (f) The Contractor shall provide the necessary database software licenses inclusive of maintenance support services.
- (g) The Contractor shall provide performance monitoring and tuning tools to facilitate the management of database performance and shall include, but not limited to the following requirements:
 - (i) Off-the-shelf Graphical User Interface (GUI) for ease of use;

- (ii) Facility to track and report on utilisation of database and system resources;
 - (iii) Detection of performance problems or bottlenecks;
 - (iv) Ability to localise source of performance issues;
 - (v) Availability of information on how to tune database;
 - (vi) Applications to maintain a healthy database; and
 - (vii) Minimal overhead on system resources.
- (h) The Contractor shall propose and implement security measures to prevent all users except those authorised, from directly accessing the database through means other than using the applications.
 - (i) The Contractor shall be responsible for the database configuration, sizing, installation, testing and the necessary setup to ensure smooth connection to the databases in the Factory Acceptance Test (FAT) and Site Acceptance Test (SAT).
 - (j) The Contractor shall maintain the database installation, configuration and maintenance document that minimally include the following areas:
 - (i) Database installation describing the detailed installation steps and configuration setting values for each environment; and
 - (ii) Database configuration and setup.
 - (k) The Contractor shall conduct database health checks and performance tuning for databases regularly.
 - (l) The proposed database software shall come with a native configurable auditing utility which shall log all database access actions when it is enabled. The audit data must be stored securely in system tables for easy retrieval and exportable to widely used formats such as Report (RPT) and Comma Separated Value (CSV).

5 Traffic Control and Surveillance System

5.1 Traffic Control and Surveillance System (TCSS) and Field Equipment

5.1.1 General

This part of the Specification describes the minimum operational and design requirements of the following TCSS and field equipment and

processes and shall be read in conjunction and other Clauses of the Specification:

- (a) Automatic Incident Detection System (AID);
- (b) CCTV Surveillance System;
- (c) Web Cameras (Webcam); and
- (d) Traffic Barrier System.

5.1.2 The Contractor shall refer to **TS Appendix A-5** for the schedule for TCSS control and monitoring I/O points.

5.2 Automatic Incident Detection System

5.2.1 General

- (a) The Automatic Incident Detection (AID) shall a programmable computer system capable of performing incident detection and traffic data collection in the KPE/MCE.
- (b) The AID shall comprise the following components, but not limited the following:
 - (i) AID servers;
 - (ii) AID processors;
 - (iii) Keyboard Video Monitor (KVM) workstations;
 - (iv) AID communication network;
 - (v) Full High Definition (FHD) Power over Ethernet (PoE) AID cameras; and
 - (vi) Necessary devices and accessories.

5.2.2 The Contractor shall use the existing network to interlink all AID servers and AID processors.

5.2.3 The Contractor shall design, supply and deliver to KPE/MCE VBs for the new AID cabinets/racks, based on the proposed AID system.

5.2.4 The Contractor shall provide power supply to all AID equipment.

5.2.5 The Contractor shall provide real-time traffic operational data (volume, occupancy, speed) for KPE/MCE, based on AID cameras configured as collection of traffic data to ITPMS.

5.2.6 The existing watermist cameras are used for viewing water mist activation in the KPE tunnels.

- 5.2.7 The Contractor shall design, configure, test and commission all the AID cameras including the existing watermist cameras according to the lane markings in KPE/MCE for incident detection and traffic data collection.
- 5.2.8 The Contractor shall coordinate with Employer's appointed contractors to stream existing watermist cameras images to the new AID system.
- 5.3 AID System Configuration
- 5.3.1 Servers and Configuration
- (a) The AID servers shall be designed to be fully redundant, modular and easily expandable and shall exhibit a high level of availability. It shall operate in a primary/backup hot-standby configuration and shall continuously perform self-checks to detect any malfunction within the system hardware and software. Redundant servers shall be provided in VB1 and VBD. The automatic failover of the AID servers within VB shall be seamless and without any data loss. The automatic failover of the AID servers from VB1 to VBD shall be seamless within one (1) minute and without any data loss.
 - (b) The AID servers shall be of high-speed microprocessor based control modules with automatic changeover facilities to ensure continued operation following any single point failure. The AID servers shall act as the interface between the ITPMS and the field equipment.
 - (c) For MCE, AID cameras shall be connected to the new Power over Ethernet (PoE) switches and the PoE switches shall be connected to existing network switches located in the nearest tunnel niches.
 - (d) For KPE depressed roads, at-grade roads, slip roads and open expressway, AID cameras shall be connected to the new Power over Ethernet (PoE) switches and the PoE switches shall be connected to new network switches located in the VBs. These new networks switches shall then connect to existing distribution switches located in the VBs.
 - (e) For KPE tunnels, existing watermist cameras in the tunnels shall be used to stream images to the new AID backend system for performing AID functions.
 - (f) The Contractor shall provide and install new cables for new AID system as illustrated in **TS Appendix A-1**.
 - (g) Each new Power over Ethernet (PoE) switch shall connect up to maximum of four (4) cameras with minimum 30% spare ports.

- (h) All communication and data transmitted between AID servers and AID processors shall be via redundant Local Area Network (LAN) connections, based on fibre optic technology.
- (i) Failure of either LAN connection shall not affect the operation of the system in terms of the ability of the AID servers and the processors to interchange data and neither shall it result in any loss of data.
- (j) The AID servers shall serve as a data concentrator and communication processor. In addition, the AID system shall have sufficient memory buffer for program running, database of incidents and traffic statistics before these events can be retrieved by ITPMS.
- (k) The AID processors shall be located in the ventilation buildings and shall be able to collect traffic data and perform incident detection. The AID processor shall provide a screenshot of the incident detection and stored in the AID system. The retrieval of these screenshots shall be available from ITPMS.

5.3.2 AID System Requirements

- (a) Operational Requirements
 - (i) Automatic Incident Detection (AID) cameras shall be provided and installed at various locations in the tunnels, on the tunnel approaches, depressed roads and on open expressway.
 - (ii) The AID sub-system shall generate alarms to be automatically raised at the KPE/MCE OCC and SOCC if there are incidents that disrupt normal traffic movements.
 - (iii) An incident shall be any event which causes a perturbation of traffic flow and which persists for more than 20 seconds. Parameters used in the AID algorithms shall all be configurable.
 - (iv) The AID system shall be capable to detect the incidents on all types of lanes under any traffic conditions including stopped vehicle, traffic slowdown, traffic congestion, slow vehicle, pedestrian, reverse flow, loss of visibility and debris.
 - (v) The AID system shall also be able to detect bicycles including power-assisted bicycles, Personal Mobility Device (PMD) such as e-scooter.
 - (vi) When an incident is detected by the AID camera, the AID servers report the incident to ITPMS. The ITPMS will alert the OCC operator to the incident. The response time from

detection of incident by the AID cameras to the generation of alarms at ITPMS shall be within four (4) seconds.

- (vii) AID cameras shall provide 100% AID detection coverage and recording of the KPE/MCE tunnels including slip roads. The Contractor shall conduct a study to ensure that there is 100% AID detection coverage in the tunnels and slip roads based on existing AID locations. In the event that the coverage is not 100%, the Contractor shall provide and install additional AID cameras in the tunnels and slip roads. The final locations of AID cameras shall be subjected to SO's acceptance.
- (viii) AID cameras shall also provide AID detection coverage based on existing AID detection coverage and recording of the KPE/MCE at-grade roads, depressed roads and on open expressway.
- (ix) Detection zones shall also be provided in advance of each interchange and all slip roads shall also be covered by AID cameras. Signals from the AID cameras shall be used to perform separate analyses for each traffic lane to determine vehicle speeds, volume and occupancy.
- (x) The main purpose of the AID camera is to identify the potential occurrence of the incidents in a traffic stream by analysing the traffic flow characteristics. The output of the AID function form the basis for incident verification and implementation of traffic plans by the OCC operator.
- (xi) The Contractor shall propose algorithms for use in detection of traffic incidents. It is anticipated that a range of algorithms shall be required to deal with different levels of traffic flow and to cater for the various situations in the tunnels, at-grade roads and open expressway. The detection parameters shall be adjustable to adapt to the changing traffic conditions to achieve optimal performance. Algorithms shall be proposed with full descriptions and details of implementations as part of the Contractor's design submission.
- (xii) The AID algorithms shall be able to distinguish between traffic congestion and a genuine incident condition. Following an incident, the AID system shall raise alarm for all genuine incidents accurately and instantly.
- (xiii) Faulty cameras shall be identified and reported to ITPMS.

- (xiv) On detection of an incident, an alarm shall be instantly sent from the AID system to ITPMS, and ITPMS will generate an alarm to allow the OCC operator to patch the AID video image onto ITPMS monitors, CCTV monitors and the video wall in the OCCs.
- (xv) The AID system shall recognise that traffic congestion may be caused by the incident and shall avoid raising further alarm in the same traffic lane in the immediate vicinity.
- (xvi) All the AID images shall be displayed on the AID system in order to facilitate the maintenance staff to calibrate the AID cameras as well as to carry out the maintenance of the AID system.
- (xvii) The AID camera shall be able to operate in a range of lighting condition from 100k lux to 1 lux.
- (xviii) The system shall generate report of detection rate of each AID camera for ease of maintenance and operation.
- (xix) The AID images shall be recorded for the operator to retrieve instantaneously if there is any incident. The AID video shall be made available in the main OCC and SOCC for viewing and retrieval of the incident images.
- (xx) The AID images shall be recorded at a minimum frame rate of 25 images per second (ips) with 1920 by 1080 pixels for 24 hours a day, 7 days a week. The images shall be stored for at least one (1) month. The OCC operator could retrieve the recorded AID images for incident investigation.
- (xxi) The operator shall be able to use the CCTV keyboard or mouse inputs to select, patch and view the AID images on CCTV monitors and video wall.
- (xxii) For MCE, besides incident detection and traffic data collection, the new AID cameras shall also be able to view deluge zones in the tunnels. The Contractor shall configure the deluge zones in the AID system and ensure that all the deluge zones are able to be viewed by operator from AID cameras. A maximum of three (3) deluge zones or approximately 75m shall be viewed by each AID camera. There shall be overlap coverage between the cameras. The camera in front shall also be configured to view the last deluge zone monitored by rear camera. The overlap coverage configuration shall be finalised in the design phase.

- (xxiii) For KPE, the watermist zones had been configured and can be viewed via existing watermist cameras in the KPE tunnels.

(b) Design Requirements

- (i) The Contractor shall provide and install all AID cameras, mounting hardware including mounting poles, secondary supports, processing units, ancillary processing and interfacing electronics, lightning protection devices, cables and accessories to form a fully operational AID system.
- (ii) The Contractor shall provide and install bracing system for mounting poles which are near tunnel ventilation fans and jet fans, to resist wind loads generated by the tunnel ventilation fans and jet fans. The design of the bracing system shall subject to the SO's acceptance.
- (iii) AID system shall be capable of detecting all vehicles with two or more wheels travelling at speeds between 0 and 160 km/h, for the following vehicle classification:
 - (I) Class 1: Motorcycles (approximately 0-2.5m);
 - (II) Class 2: Passenger Cars and taxis (approximately 2.5-5m);
 - (III) Class 3: Pick-ups, vans, light goods vehicles and small lorries (approximately 5-7m);
 - (IV) Class 4: Single-decker buses, medium and large lorries, container trucks (approximately 7-12m); and
 - (V) Class 5: Large buses, heavy commercial vehicles with or without trailer (approximately 12-30m).

The AID system vehicle classification in terms of the vehicle length shall be configurable. The Contractor shall coordinate with ITPMS contractor on the vehicle classification. All interface details shall be discussed and agreed by ITPMS contractor and the Contractor. The proposed AID system vehicle classification shall be subjected to the acceptance of the Superintending Officer.

- (iv) Traffic data including traffic statistic and incident detection data collected, by the AID system, shall be provided to ITPMS. Traffic data shall consist of speed, volume, occupancy per lane and tunnel sections and classified into the respective vehicle classes.
- (v) The following traffic data based on per lane, per tunnel and open expressway sections shall be provided:

- (I) Average speed (km/h);
 - (II) Volume (vehicle/hr);
 - (III) Lane occupancy (%);
 - (IV) Average headway (m);
 - (V) Average vehicle length (m);
 - (VI) Average delay (second); and
 - (VII) Average vehicle classes (minimum 5 classes, differentiated by vehicle length) and its flow (vehicle/hr).
- (vi) The exact location of the AID cameras shall be coordinated and agreed with the Superintending Officer (SO). Live traffic videos for real-time detection of vehicles and incidents shall be provided by colour video cameras with fixed-lens type. These AID cameras shall be provided for the sole purpose of functioning as the image sensors for the AID system.
 - (vii) The Contractor shall provide full AID coverage for all traffic lanes in the tunnels including slip roads. To ensure full coverage, the Contractor's detailed design shall take into account of entrances, exits, tight bends, curves, straights and gradients in the tunnel.
 - (viii) The Contractor shall submit detailed design for installation and placement of AID cameras for acceptance by the SO. In addition to AID detection, the video images from the AID camera system as seen by the operator shall coincide and match the MCE deluge zones.
 - (ix) The Contractor shall refer to the MCE deluge drawings provided to facilitate the detailed design. Additional overlay deluge zone marking shall be added to the images.
 - (x) The image sensor and lens of AID camera shall be housed in an environmental enclosure with the following functions and capabilities. The AID camera shall be a fixed FHD PoE camera. It shall have proven operation references for expressway and tunnel applications with similar mounting arrangements comparable to those required, for this Contract.
 - (I) Enclosure shall be rated to IP66 or better;
 - (II) Enclosure shall allow AID camera position to be rotated in the field during installation;

- (III) Enclosure shall include a provision at the rear for connection of PoE cables fabricated at the factory; and
- (IV) The enclosure shall be light-coloured and shall include a sun shield, where applicable to minimise solar heating. The front edge of the sun-shield shall protrude beyond the front edge of the environmental enclosure and shall include provision to divert water flow to the sides of the sunshield. The amount of overhang of the sun-shield shall be adjustable to prevent direct sunlight from entering the lens.
- (xi) The Contractor shall provide AID cameras junction boxes, poles and mounting brackets.
- (xii) The AID cameras shall be positioned at sufficient heights and orientation to provide the specified detection requirements and accuracy. The cameras shall be securely mounted on to the support structure. The Contractor shall identify strategic locations, height and orientation for mounting of AID cameras to ensure that the performance requirements of AID system are met and that all cameras shall provide good accessibility for maintenance purposes.
- (xiii) The Contractor shall demonstrate to the SO that the AID cameras are accurate, reliable and are not affected by weather and vibration.
- (xiv) The image processing units shall retain required set up data upon power failure and shall be able to resume operation automatically upon resumption of power supply.
- (xv) The AID system shall interface with ITPMS for exchange of data.
- (xvi) The Keyboard Video Monitor (KVM) workstations shall be placed in the cabinets/racks at ITPMS room at VB1 and Computer room at VBD. It shall be able to function as maintenance terminal for real-time monitoring of vehicle detection and AID by the image processing units. The KVM workstation shall allow the user to select the traffic parameters to detect and derive traffic incidents.
- (xvii) The AID system shall be equipped with hardware and software to support video capture function and to produce selected live traffic video to be displayed on the monitor of the Keyboard Video Monitor (KVM) workstation. It shall be

possible to obtain a video image (snapshot) from selected AID camera video using the KVM workstation.

- (xviii) Field equipment required for AID system within the KPE/MCE tunnels shall be housed in tunnel niches. All AID cameras shall be protected by local miniature circuit breakers.
- (xix) AID equipment located outside the tunnel shall be housed in weatherproof junction box of IP66 standard that shall be suitable for both pole-mounting and also for mounting on the base of gantries. The junction box shall contain any necessary power supply equipment.
- (xx) Traffic data collected at one (1) minute intervals over an hour or other selected time intervals shall be stored in the AID servers and send to ITPMS.
- (xxi) The AID servers shall be equipped with sufficient secondary storage device for archiving of three (3) months traffic statistical and incident detection data. All archived traffic data shall be retrievable at the KVM workstation for viewing, analysis and report generation.
- (xxii) The AID camera units are intended to be mounted onto the tunnel ceiling or soffit of the tunnels, on the poles along the slip roads and open expressway.
- (xxiii) AID cameras mounted overhead shall be suitable for accurate detection of the entire vehicle parameters necessary for the AID algorithm and the collection of traffic statistics.
- (xxiv) The cameras and poles shall be positioned to provide the specified detection requirements. The cameras shall be securely mounted on the support structure and shall not require routine readjustment of the installation set up.
- (xxv) After installation of the vehicle detection equipment, the detectors shall be properly set up and tuned for system operations. Records for the set-up of each camera shall be submitted no later than two (2) weeks after completion of the set up process for the camera. The records shall also be incorporated in the maintenance document supplied under this Contract.
- (xxvi) The AID system shall be able to detect vehicle as a standalone unit, calculating traffic parameters in real-time and reporting to the ITPMS. Failure of any individual image

processing unit shall not cause any malfunction of the entire AID system.

- (xxvii) False alarm rates for incident detection of the AID camera shall not be greater than 2% and 5% during the normal and adverse conditions respectively. Adverse conditions shall refer to 50% NIGHT illumination level in tunnel, raining condition, sunny or overcast sky for at-grade roads, wet road condition and shadows. The accuracy for collection of individual traffic data parameter shall not be less than 95%.
- (xxviii) The AID system shall provide accurate real time traffic which shall be verified during tunnel operation. The criteria for verification shall be discussed and finalised during the project stage.
- (xxix) The AID system shall be capable to mitigate the adverse impact on the accuracy of traffic parameters arising from vehicle shadows, where applicable, during daytime and vehicle spotlights at night.
- (xxx) Off-the-shelf GUI shall be provided at the Keyboard Video Monitor (KVM) workstation for the creation and modification of the detection zones to be recognised by the image processing units for vehicle detection and incident detection. Detection zones shall be detected by drawings of lines and boxed within the field of view of respective AID cameras. Such construction of drawings shall be superimposed or overlaid on the video image of traffic displayed on the video monitor of the KVM workstation.
- (xxxi) It shall be possible to define detection zones anywhere and at any orientation within the combined field of view of the AID cameras. The detection zones shall be capable of being sized, shaped and overlapped to provide the optimal road coverage and detection.
- (xxxii) The user shall be able to redefine or fine-tune any previously defined detection zone in respect of its size, shape and position using the Keyboard Video Monitor (KVM) workstation. Once a detection configuration has been created, the KVM workstation shall provide a graphic display of the configuration on its screen display.
- (xxxiii) AID configuration settings, including definitions of detection zones, shall be stored on disk as a file, which can be downloaded to the image processing units for immediate execution.

- (xxxiv) When a vehicle is under a detection zone, the monitor of the KVM workstation shall display the status change for vehicle presence and other selected real-time traffic parameters to verify the operation of the AID system.
- (xxxv) In addition to detection of stopped vehicle, the AID system shall be able to detect congestion, in which vehicle speed decreases gradually over the entire road section. Based on average traffic speed and other traffic data such as lane occupancy and volume, severity of congestion shall be derived for respective road sections bounded by the designated detector stations as follows, with threshold to be user configurable:
 - (I) No congestion – persistent free traffic flow with average speed of 60 km/h or higher.
 - (II) Moderate congestion – persistent medium traffic flow with average speed of 41 to 60 km/h.
 - (III) Heavy Congestion – persistent high traffic flow with average speed of 20 to 40km/h.
 - (IV) Very Heavy congestion – persistent heavy traffic flow with average speed below 20 km/h.
- (xxxvi) The analysis output shall be conveyed to the ITPMS.
- (xxxvii) The Contractor shall furnish and install all cables and connectors for connecting all AID cameras and image processing units for transmission of video signals.
- (xxxviii) All data and videos shall be downloadable to external storage devices such as thumb drive.

5.3.3 Traffic Flow Statistics

- (a) General
 - (i) The AID system shall be able to generate traffic statistics report both on demand and automatically.
 - (ii) The contents of traffic statistical reports and the format of the report shall be user-definable and the incorporate an easy to use menu driven interface.
 - (iii) Traffic data shall be provided for traffic at both bounds traffic of the KPE/MCE.
 - (iv) Traffic data shall be stored in the AID servers as historical records for a period of up to three (3) months from the time of retrieval from the image processing units of the AID

system. Any stored or archived traffic data shall be available at the Keyboard Video Monitor (KVM) workstation for viewing or report and printing if require.

- (v) Traffic data stored in the AID servers shall be available for compilation of traffic statistics reports. The reports shall be formatted for easy comprehension and shall be available for display on the KVM workstation and printing if require.
- (vi) The Keyboard Video Monitor (KVM) workstation shall provide flexibility in formatting traffic statistics reports such as table of numerical traffic data versus time series and histogram.
- (vii) Real-time traffic parameters shall be made available to ITPMS for overlaying over the sectional road network map shown on the video wall.
- (viii) The Contractor shall determine at site the optimum locations of AID cameras to meet the traffic data requirements.
- (ix) The real-time traffic parameters for incident detection shall also form the basis for compilation of traffic statistics, which shall be stored and retrievable from the system and displayed on the KVM workstation. At all AID traffic monitoring sites, it shall be possible to configure the system to collect, store, and report traffic flow statistics as measured at each site. At any one time it shall be possible to configure a minimum of eighty-six (86) such sites for collection of statistics. The AID system shall be configured for statistics generation at each AID camera locations and the locations to be selected in consultation with the SO.
- (x) Statistics of traffic volume, occupancy, vehicle length, and speed shall be collected from the AID cameras in each lane at the selected AID zones.
- (xi) The statistics shall be arranged to be viewed as reports. The exact details, format and frequencies of the reports generation shall be subject to the acceptance of SO.
- (b) The AID algorithm shall compare and evaluate traffic parameters collected by AID cameras to determine whether an incident has occurred.
- (c) To evaluate the effectiveness of the AID system, three (3) basic measures of effectiveness commonly used are defined as follows:

- (i) Detection rate – the percentage of incidents which are detected by the algorithm out of all the true incidents that have occurred in a specified time period;
 - (ii) False alarm rate – the percentage of false incident messages out of the total number of messages during a specified time period; and
 - (iii) Mean time to detect – the mean delay time between the occurrence of the incident effect and the time that the incident is first detected.
- (d) During heavy traffic conditions, compression waves are prevalent in the traffic stream and are often the cause of false alarms. Compression waves are defined as waves of slow moving or stopped vehicles. As a vehicle approaches slow moving traffic, it must decelerate and the gap between vehicles is reduced. This movement has a wave effect because the next vehicle must proceed in the same manner. The AID algorithm shall contain features to distinguish between flow during compression waves and that which occurs during incident conditions.
- (e) Many flow disturbances in incident-free traffic are short-lived. A persistence check is to be developed for AID algorithms to ensure that incident pattern lasts for a few algorithm iterations before issuing an alarm.
- (f) The proposed AID system shall be proven and have been used in a known Traffic Control and Surveillance System similar to the road tunnel environment, subject to the SO's acceptance.
- (g) The AID algorithm shall meet all performance requirements under various traffic conditions ranging from light to heavy traffic flow. The AID algorithm shall be able to detect all types of incidents. Measured traffic flow parameters such as volume, occupancy and speed may be used to select the most appropriate algorithm for various traffic conditions.
- (h) The AID algorithm shall be able to perform lane-by-lane incident detection.
- (i) The AID algorithm shall be able to deal with road sections with different geometry, merging and diverging traffic, as well as with lane drop and lane gain. The AID system shall contain features which group AID cameras of different road sections together. It shall be feasible for different sets of calibration parameters to be selected for different groups of AID cameras.

- (j) The AID algorithm shall contain features to distinguish compression waves from incident during congestion period.
- (k) The AID algorithm shall contain features to reduce false alarm during heavy traffic flow.
- (l) The algorithm shall be provided with calibration features such that all adjustable parameters can be tuned to obtain an optimal performance. User interface shall be provided in the Keyboard Video Monitor (KVM) workstation to enable the operator to select and modify all these parameters.
- (m) The Contractor shall propose for the SO's acceptance an AID algorithm for use in detection of incidents. If a number of algorithms are employed, software shall be provided in the AID system to automatically select the most appropriate algorithms based on traffic conditions. The AID system shall also be capable of concurrently running different algorithms for different sets of AID cameras.
- (n) Types of Traffic Statistics
 - (i) The AID system shall be able to collect one (1) minute volume and vehicle length statistics. Occupancy shall be measured on one minute basis for each lane.
 - (ii) One (1) minute statistics shall be stored and readily accessible for a period of at least three (3) months after collection.
 - (iii) The system shall process the one (1) minute statistics into one-hour statistics for long term storage and generation of long term reports whenever required.
 - (iv) Traffic statistics reports shall be generated both on demand and automatically.
- (o) Contents of Traffic Statistics Reports
 - (i) Traffic statistical reports shall be available to show:
 - (I) Traffic volume and occupancy by tunnel bound and by tunnel lane;
 - (II) Traffic volume and occupancy by selected camera for each lane;
 - (III) Traffic volume by speed range for selected camera and for tunnel bound; and
 - (IV) Traffic volume by vehicle length range for selected camera and for tunnel bound.

- (ii) For reports requested pertaining to data wholly collected within the previous one (1) month the resolution of the reports shall be selectable from the values of 5 minutes, 15 minutes, 30 minutes, hourly, and daily. The starting time for daily reports shall be programmable.
 - (iii) For reports requested pertaining to data collected the reports shall be selectable from the values of hourly and daily.
 - (iv) The format of presentation of the reports shall be user-definable and shall incorporate an easy to use menu driven interface.
- (p) Traffic data requirements
 - (i) Traffic data shall be provided for KPE/MCE tunnels, slip roads and open expressway.
 - (ii) All classes of traffic data shall be collected and recorded by AID system and sent to ITPMS. Traffic statistical data shall be obtained from the traffic statistics stations. Incident detection data shall be obtained from the AID cameras for incident detection and algorithm calibration purposes.
 - (iii) AID cameras for the collection of either traffic statistical data or incident detection data shall be selectable by the operator through the Off-the-shelf GUI of the Keyboard Video Monitor (KVM) workstation.
 - (iv) Traffic data shall be checked against pre-defined realistic boundaries proposed by the Contractor. Any traffic data falling outside the realistic boundaries shall be marked as questionable data.
 - (v) In the event that an AID camera or its associated equipment is faulty, such camera and its associated equipment shall be logged and the associated data shall be marked as problem data.
 - (vi) Data collected from traffic statistic cameras shall be available for display and printout on demand by operator in the OCCs. The data shall also be stored as historical records for a period of a minimum of three (3) months from the time of collection.
 - (vii) The following traffic statistical data reports are required, but not limited to the following:

- (I) Poll cycle data per camera lane – volume, occupancy, average speed and average vehicle length;
 - (II) One (1) minute data per camera lane – total volume, occupancy, average speed and average vehicle length;
 - (III) Hourly data per camera lane – total volume, average speed and average vehicle length;
 - (IV) Daily data per camera lane – total volume and average vehicle length;
 - (V) Poll cycle data per processor which is a group formed by grouping one or more cameras together.
 - (VI) Volume, occupancy, average speed and average vehicle length;
 - (VII) One (1) minute data per processor – total volume, occupancy, average speed and average vehicle length;
 - (VIII) Hourly data per processor – total volume, average speed and average vehicle length;
 - (IX) Daily data per processor – total volume and average vehicle length;
 - (X) Vehicle length data is collected by counting the number of vehicles in each of the user defined length class;
 - (XI) The Contractor shall propose for the acceptance of the Superintending Officer (SO) on the format of the display and printout of the above traffic statistical data report in the design submission; and
 - (XII) Data collected from AID cameras shall be available for display and printout on demand by the operator. The data shall be stored as records for a period three (3) months after collection. It shall be possible to download the data reports for any period of time within three (3) months of collection.
- (viii) The Contractor shall propose for the SO's acceptance the format of the display and printout of the above incident detection data report in the design stage.

5.3.4 CCTV Surveillance System

5.3.4.1 General

- (a) The CCTV surveillance system shall enable the operator to identify vehicles and personnel involved in traffic accidents and incidents through video images provided by the surveillance cameras. The Contractor shall ensure that the proposed locations and positioning of the cameras achieve surveillance coverage throughout the KPE/MCE.
- (b) The primary objective of the CCTV surveillance system is to provide a suite of high-performance surveillance cameras at the field to transmit colour pictures video images for real-time monitoring at OCC and SOCC.
- (c) The Contractor shall be responsible for the complete installation of the colour CCTV surveillance system including the provision of all supporting accessories required for mounting of the cameras in KPE/MCE tunnels, outside the tunnels and emergency escape staircases. The equipment to be provided shall include, but not limited to the items listed below.
 - (i) Full High Definition (FHD) PoE cameras with pan-tilt-zoom (PTZ) functions, mounting and housing and have proven operation references for expressway and tunnel applications with similar mounting arrangements specified under this Contract;
 - (ii) Cameras control equipment;
 - (iii) CCTV workstations and servers;
 - (iv) FHD PoE web cameras ;
 - (v) Video Management System (VMS);
 - (vi) Network Video Recording (NVR) system;
 - (vii) All necessary video accessories to facilitate flexible camera-to-monitor correspondence scheme; and
 - (viii) All necessary cabling, poles, mounting brackets and network equipment to support the CCTV surveillance system.
- (d) The Contractor shall determine on site the exact locations for installation of the surveillance cameras and submit details to SO for acceptance before installation.
- (e) Pan-tilt-zoom (PTZ) mechanisms shall be available for all surveillance cameras. The pointing direction of the cameras shall be remotely controlled by a PTZ controller for effective

camera rotation in azimuth (panning) and elevation (tilting). The PTZ mechanisms and manual iris override control for all surveillance cameras shall enable the operator to obtain live traffic videos of either approaching or receding traffic from the same surveillance camera. All surveillance cameras shall support zooming operation in addition to the PTZ mechanisms. By virtue of the PTZ capabilities, each camera shall have a large dynamic field of view capability. With full coverage and strategically positioned surveillance cameras, the CCTV surveillance system shall provide seamless surveillance pictures for the tunnels, cross passage doors, escape doors, etc and its vicinity, including depressed roads, at-grade roads, tunnel entrances/exits, etc.

- (f) All outdoor and tunnel CCTV cameras shall be provided with lightning and/or voltage protection devices to prevent damage from lightning and voltage surges.
- (g) All cameras shall provide 100% coverage based on existing CCTV camera location and recording throughout both bounds of the tunnel, all emergency niches, tunnel escape staircase doors at tunnel any corridor leading to the escape staircase, passenger cross passage doors, vehicle cross passage doors, portals, at-grade roads leading into the tunnel and all slip roads without the need to pan, tilt or zoom any of the cameras. On the slip roads and open expressway, cameras shall be erected on poles at strategic locations in order to provide 100% surveillance coverage.
- (h) CCTV cameras shall provide 100% frontal coverage of the emergency Escape Staircases (ES) (at grade door) and 100% coverage of the ES perimeter. There are sixty-four (64) emergency ES along KPE/MCE. The Contractor shall provide PTZ dome cameras for ES and determine on site the exact locations for installation of the surveillance cameras and submit details to SO for acceptance before installation.
- (i) The CCTV surveillance system shall include features to allow for the programming, configuration and assignment of CCTV cameras to view tunnel emergency niche doors, tunnel escape doors, tunnel emergency telephone doors, etc. Upon receiving control command from ITPMS, the CCTV surveillance system shall automatically pan the designated camera to view the location of the door that trigger the door open alarm at ITPMS. The Contractor shall be finalised the method and type of interface/protocol with ITPMS contractor during the design phase.

- (j) The CCTV surveillance system shall include user-friendly CCTV workstations to provide effective system control functions. Each CCTV workstation shall allow the operator to exercise control over individual camera. Surveillance camera control functions shall include pan-tilt-zoom motion and iris focusing functions.
- (k) The CCTV workstations shall provide GUI interface to allow live video from any of the CCTV cameras to be displayed at any of the video monitors at the CCTV workstations and the video wall.
- (l) In the event when dedicated video monitor corresponding to a camera becomes unavailable, the CCTV surveillance system shall allow the operator to retrieve the lost video stream on any operating video monitors and video wall.
- (m) The operator shall be allowed to program the following ad-hoc display mechanisms:
 - (i) Time sequential display of a series of selected camera videos on any selected video monitors;
 - (ii) Time sequential display of a series of selected camera videos on a section of the video wall in the OCCs;
 - (iii) Quadrant size display of four (4) CCTV camera videos on any selected video monitors;
 - (iv) Quadrant size display of four (4) CCTV camera videos on a section of the video wall in the OCCs; and
 - (v) The number of CCTV camera videos to be displayed on any selected video monitors and video wall shall be configurable.
- (n) Transmission of video signals and control signals between the central processing equipment and various surveillance cameras shall be achieved by using existing independent fibre-optic transmission system, separated from the communication system network.
- (o) All CCTV cameras shall be protected by local miniature circuit breakers. When any of these miniature circuit breakers is tripped, an CCTV alarm shall be relayed to the ITPMS.
- (p) The Contractor shall design and supply a high performance video signal transmission system, which incur minimum loss or distortion and protected from noise or interference.
- (q) All pictures displayed on the CCTV surveillance system video monitors shall have time and date annotations.
- (r) The response time for all video switching electronics shall be quasi-instantaneous, meaning that there shall be no discernible

delay in switching the camera through other processing equipment. For motion control of cameras, including pan-tilt-zoom and iris controls, the time lag between the activation command at the OCCs and the actual commencing of motion shall not be more than 0.5 second.

- (s) All CCTV cameras and central processing equipment shall be solid-state and reliable. The CCTV surveillance system shall be designed to operate continuously under single point failure in the transmission medium where a multi-signal single-fibre transmission scheme is employed.
- (t) For MCE, CCTV and web cameras shall be connected to the new PoE switches and the PoE switches shall be connected to existing network switches located in the nearest tunnel niches.
- (u) For KPE, CCTV and web cameras shall be connected to the new PoE switches and the PoE switches shall be connected to new dedicated network switches located in the VBs. These new dedicated networks switches shall then connect to existing distribution switches located in the VBs.
- (v) The Contractor shall provide and install new cables for new CCTV system as illustrated in **TS Appendix A-2**.
- (w) Each new Power over Ethernet (PoE) switch shall connect up to maximum of four (4) cameras with minimum 30% spare ports.
- (x) CCTV video shall be recorded and snapshot shall be captured into the CCTV Network Video Recording (NVR) system and servers at ITPMS room at VB1 and Computer room at VBD.
- (y) The IP-based surveillance system shall comply with specification of Open Network Video Interface Forum (ONVIF) for inter-operability between IP-based network video devices.
- (z) The video management system shall have a distributed fault-tolerant, failover database architecture and have networking capabilities to communicate with each other. The distributed server architecture allows to operate in an independent mode, without affecting video recording or live viewing. The replicated database shall be initially and continuously synchronised with the master database to ensure that it is always up to date and ready for failover.
- (aa) The video management system shall offer Off-the-shelf GUI for global settings. Global settings shall allow user to quickly retrieve, configure and apply the following parameters:

- (i) All camera configurations shall include the following as a minimum:
 - (I) Bitrate, resolution, frame rate, multicasting and unicasting for video stream of camera;
 - (II) Priority level of CCTV user in camera access and PTZ control;
 - (III) White balance, saturation, exposure, contrast of camera;
 - (IV) Camera mask (privacy zones); and
 - (V) All recorder configurations including recording bitrate, resolution, frame rate for each camera.
- (bb) The Contractor shall design, supply, deliver to site, install, test and commission the workstations for CCTV surveillance system, the LED bezel-less monitors provided shall be of a minimum 24-inch and the minimum quantity of the workstations is indicated below.
 - (I) OCC (six (6) workstations with a minimum 24-inch LED bezel-less monitor each, mouse each and CCTV keyboard each) at KPE/MCE VB1;
 - (II) SOCC (six (6) workstations with a minimum 24-inch LED bezel-less monitor each, mouse each and CCTV keyboard each) at KPE/MCE VBD;
 - (III) Conference room (two (2) workstations with a minimum 24-inch bezel-less LED monitor each, mouse each and CCTV keyboard each) at KPE/MCE VB1; and
 - (IV) Computer room (two (2) workstations with a minimum 24-inch LED bezel-less monitor each, mouse each and CCTV keyboard each) at ITSC.
- (cc) The workstations at ITSC Computer room shall allow multiple users (minimum of six (6) users) to log in simultaneously to view and control KPE/MCE cameras. The Contractor shall provide IP KVM transmitters to connect to existing IP KVM network to allow operator in ITSC OCC to remotely access the workstations in ITSC Computer room.
- (dd) The Contractor shall coordinate with the maintenance and EMAS contractors to use and configure the existing bandwidth of the communication link to cater for the video channels between the KPE/MCE OCCs and ITSC.

- (ee) The Contractor shall liaise, interface and coordinate with Singapore Police Force (SPF) and Singapore Civil Defence Force (SCDF) to ensure that CCTV cameras in KPE/MCE can be viewed and controlled from SPF and SCDF. A joint statement shall be signed by both interfacing parties in the Interface Control Document (ICD) and submit for SO's acceptance.
- (ff) The CCTV surveillance system for the KPE/MCE shall also be able to receive the video signals from the ITSC CCTV system, to control the CCTV cameras of the existing ITSC system and to select the ITSC CCTV cameras to display on the KPE/MCE CCTV system in the OCCs.
- (gg) Proper computerized video switching facilities shall be provided to permit the video from a number of cameras to be displayed on each monitor, either as selected by the operator or by program.
- (hh) Detailed CCTV surveillance system proposal with all necessary detail diagrams and technical descriptions shall be submitted to the SO for review and acceptance. The block diagram shall be accompanied with detailed descriptions and diagrams of all major units and interfaces of the proposed system including relevant electrical characteristics, data protocols and functions.

5.3.4.2 CCTV System Configuration

- (a) The cameras shall be mounted on poles, on sign gantries or on brackets along KPE/MCE. It shall be completed with IP66 weather-proof housings and self-cleaning accessories. Locations shall be finalised as part of the Contractor's design and subject to the SO's acceptance. Video transmission between the cameras and OCCs as well as ventilation buildings shall use optical fibre techniques. The video monitors shall be installed in the OCCs and the buildings, from where the cameras shall be remotely controlled over the common data transmission system.
- (b) The Contractor shall coordinate with the Employer's appointed contractors to use and configure the existing optical fibre communication network for video transmission.

5.3.4.3 CCTV Field Equipment

- (a) FHD PoE Camera
 - (i) A camera shall consist of, but not limited to the following items:

- (I) Colour camera, complete with an environmentally sealed housing, automatic iris and zoom lens;
 - (II) A pan and tilt head;
 - (III) A pole or other camera mounting;
 - (IV) Wiper fitted to clean the exterior of the window for the housing of the bullet camera;
 - (V) Camera video transmitter and control equipment installed in a junction box;
 - (VI) Local cabling for video transmission and camera control circuits from the camera junction box to the longitudinal cable network;
 - (VII) Local cabling of the power supply to the camera junction box;
 - (VIII) Local cabling from the camera junction box to the camera for video, control and power circuits;
 - (IX) Anti fog; and
 - (X) Anti-dust.
- (b) Camera Housing and Pan And Tilt Head
- (i) Camera Housing
 - (I) The camera housing shall be weatherproof to IP66 standard and shall accommodate a camera complete with lens.
 - (II) The camera housing shall incorporate a hood to provide protection against direct sunlight.
 - (III) The camera housing shall not obstruct the camera's field of view.
 - (IV) A wiper shall be fitted to clean the exterior of the window for the housing of the bullet camera. The wiper shall clean the exterior of window automatically based on sensor.
 - (V) The wiper shall park automatically out of the camera view.
 - (VI) The Contractor shall ensure that the camera in its housing is suitable in all respects for operation in Singapore environment.
 - (ii) Pan and Tilt Head

- (I) The pan and tilt head shall have an arc of travel in each plane which shall be controlled by limit switches which shall be adjustable to allow 360 degrees of pan and 100 degrees of tilt. Access shall be provided so that these limits can be adjusted on site during installation and maintenance.
 - (II) The pan and tilt head shall not continue in the same direction in the event of an instantaneous reversal of direction command.
 - (III) The pan and tilt head shall be driven in two planes by reversible electric motors and provision shall be made to protect the motor under stalled conditions.
 - (IV) The drive mechanism shall not turn the mounting by more than 4 degrees beyond the point reached at the instant of removal of command to the motor.
 - (V) It shall be possible to pan and tilt the head simultaneously in response to appropriate control commands.
 - (VI) All electrical connections shall be weatherproof plugs and sockets.
- (c) Camera Pole or Other Camera Mounting
 - (i) The camera shall be mounted on pole either at-grade or on a sign gantry.
 - (ii) The Contractor shall determine the length of the pole to give the optimum range and field of view consistent with the camera supplied and its location.
 - (iii) The pole shall be protected against corrosion either by hot-dip galvanising or by a similar process, subject by the SO's acceptance.
 - (iv) The Contractor shall be responsible for the design and construction of foundations, fixtures and fittings for the camera poles and associated mountings.
 - (v) The Contractor can propose alternative mounting method for the CCTV cameras, i.e. mounting the CCTV camera on the street lighting pole for the SO's consideration and acceptance.
- (d) Camera Performance
 - (i) Cameras shall be of the high-grade industrial type for the FHD PoE cameras.

- (ii) Cameras shall be capable of operating in a range of lighting conditions from 100K lux to 1 lux.
 - (iii) Cameras shall have automatic aperture and sensitivity control. Aperture control shall be selectable between automatic and manual.
 - (iv) Cameras shall have peak white inverter circuits. The effects of “comet tailing” shall be kept to a minimum.
 - (v) The camera amplifier frequency response shall be sensibly level between 100KHz to 5.5MHz.
 - (vi) Camera resolution shall be minimum 1080p or better.
 - (vii) Camera linearity shall be such that no point shall deviate from the ideal by more than 3%. Noise in the form of hum or ringing shall not be visible on a monitor. When viewing a resolution chart having a highlight brightness of 50 lux, the signal to noise ratio shall be greater than 45 dB at aperture F/2.8.
 - (viii) The camera requiring variable focal length lenses shall be fitted with a minimum 20:1 zoom lens with a horizontal viewing angle from 20 degrees to 100 degrees.
- (e) CCTV Equipment
- (i) The OCC, SOCC, VB1 Conference room and ITSC Computer room shall house the CCTV workstations. All electronic processing, receiving, transmitting and testing facilities shall be housed in the cabinets/racks in the ITPMS room at VB1 and Computer room at VBD.
 - (ii) The new CCTV cabinets/racks in ITPMS room at VB1 and Computer room at VBD shall include a maintenance panel and monitor which allow maintenance staff to select any camera connected to the system, display the picture from that camera, and where appropriate, exercise full control over the camera. The priority of such control shall be lower than the operator in the OCCs.
 - (iii) Additional maintenance facilities shall be included to facilitate servicing and fault finding. Such facilities shall include the monitoring of video signals, confirmation of transmission of control signals to cameras, D.C. power supply monitors and test points. All connections necessary for the use of these servicing facilities shall be via removable connectors and all cables necessary shall be provided under the Contract.

- (f) Control of Cameras
 - (i) The workstations for CCTV surveillance system shall be able to control all cameras. Each workstation shall be equipped with CCTV keyboard, monitor and mouse.
 - (ii) The camera controls shall include, but not limited to the following functions, where applicable:
 - (I) Two directions of pan (left, right);
 - (II) Two directions of tilt (up, down);
 - (III) Zoom (in, out);
 - (IV) Fine control of iris (open, close);
 - (V) Auto-iris selection;
 - (VI) Fine control of focus (in, out);
 - (VII) Wiper operation (on, off);
 - (VIII) Camera selection;
 - (IX) Pre-set position selection;
 - (X) Monitor selection switch; and
 - (XI) Alarm acknowledge button.
 - (iii) It shall be possible to control pan, tilt and zoom the camera either independently or simultaneously.
 - (iv) Selection of a camera for display on a control panel monitor shall not take control of the camera. Separate provision shall be made for the operator to take control of the camera.
 - (v) It shall be possible to release a camera from control without losing its picture from the control panel monitor and without taking control of another camera.
 - (vi) At the control panel, computerized video recorders shall be provided to allow recording of the pictures displayed on the monitors under the control of the operator. The Contractor shall submit detailed technical document for assessment.
 - (vii) The CCTV images and AID video pictures shall be recorded at a minimum frame rate of 25 images per second (ips) with 1920 by 1080 pixels frames per second. The recorders shall be able to store one (1) month of recordings, allow retrieval of recordings onto DVD-ROM and other external storage media such as thumb drive via interface port.
 - (viii) The video recorders shall incorporate audio dubbing facilities to allow a commentary to be added. A suitable

microphone shall be provided which shall connect into jacks on the control panel. The operator shall be able to control, view and playback the recorded video in the OCCs.

- (ix) The video recorders shall incorporate time lapse facilities and shall allow selection from at least six (6) conveniently speeds giving a range between normal speed and one hundredth of normal speed.
- (x) The time to retrieve the recordings DVD-ROM or to external storage shall be shorter than the actual duration of the recorded video. The detail of retrieval shall be subject to SO's acceptance.

(g) System Operation

- (i) An operator shall be able to select the picture from any camera allocated to his control panel for display on workstation monitors.
- (ii) The operator shall enter the identity of the selected camera on the CCTV keyboard.
- (iii) The operator shall select the required monitor and confirm the camera selection by use of the "enter" key. The selected picture shall then appear on the appropriate monitor.
- (iv) The operator shall be able to relinquish control of a selected camera at any time, by a single key entry.
- (v) A cancellation key shall be provided to allow correction of errors.
- (vi) The operation of the CCTV surveillance system shall be detailed by the Contractor and shall be subject to SO's acceptance.

(h) Pre-set Camera Positions

- (i) It shall be possible for the operator to program eight (8) pre-set positions for each camera.
- (ii) The pan and tilt co-ordinates shall be accurate to within 5 degrees.
- (iii) When an AID incident and/or emergency telephone alarm is raised, the nearest camera to the incident shall move to a pre-set camera position.
- (iv) The Contractor shall be responsible for proper design and implementation of all necessary protocols, data formats and content for interfacing of the CCTV surveillance system with ITPMS.

- (i) Autocycle
 - (i) An autocycle is defined as the display of pictures from a number of cameras sequentially on a monitor. The number of pictures involved, the order in which they are presented and the duration of each displayed picture shall be under the control of the operator.
 - (ii) The system shall be capable of running “n” autocycles simultaneously (where n is the total number of monitors in the system). Each autocycle shall be given an identifying number.
 - (iii) The autocycle shall be set up by the operator selecting the monitor to be used and then selecting the cameras. The duration for each display shall be adjustable between 5 and 60 seconds.
 - (iv) The minimum size of an autocycle shall be two (2) cameras in sequence. The maximum size shall be “n” cameras in sequence (where “n” is the total number of cameras in the system).
 - (v) It shall be possible for an operator to seize control of an autocycle, so that the monitor displays the picture from the current camera. The duration of the display shall be extended until the operator releases control.
- (j) Character Generator
 - (i) The character generator shall produce outputs to be displayed on the monitors in alpha-numeric form to assist the operator in the control of the cameras.
 - (ii) The character generator shall produce outputs which may be used to:
 - (I) Identify the camera in use, by number and location;
 - (II) Identify the workstation in control;
 - (III) Indicate the pre-set position selected; and
 - (IV) Indicate the direction in which the camera is facing (e.g. north, south, east and west).
 - (iii) The characters shall be displayed in the top left hand corner of a monitor. Video overlay techniques may be used.
- (k) Signal Processing Equipment
 - (i) When the appropriate command from ITPMS are received, the signal processing equipment shall:

- (I) Switch the video from any camera or remote video source to either operator's workstation monitors; and
 - (II) Switch the control signals from either controller to any camera.
- (ii) The signal processing equipment shall be capable of controlling all cameras.
- (l) Timing
 - (i) The delay between selection of control and taking control of a camera shall not exceed one (1) second.
- (m) Data Communications
 - (i) The method of data transmission shall include full line integrity checks, checks for data errors and corruptions and shall be designed to ensure that normal operational occurrences do not interfere with the operation of other sub-systems.
 - (ii) Provision shall be appropriately made in the CCTV surveillance system to allow for connecting a minimum of five (5) additional video and camera control sources from remote sites to the CCTV surveillance system in future.
- (n) Alarms
 - (i) The alarms for the CCTV surveillance system shall send to the ITPMS in the OCCs, but not limited to the following:
 - (I) Power failure at any location;
 - (II) Control data fault;
 - (III) Cable break;
 - (IV) Transmission degradation in any transmission system;
 - (V) Equipment removal or failure; and
 - (VI) Limit switch failure or malfunction.

5.3.4.4 Network Video Recording System

- (a) The Contractor shall propose, design, size, develop and configure a Network Video Recording (NVR) system, to view and record all CCTV and AID video images, in ITPMS room at VB1 and Computer room at VBD. All necessary hardware, middleware, software and network equipment shall be designed, supplied, delivered, installed and developed for the system.

- (b) The Contractor shall design the NVR system for any failover of within VB shall be seamless and without any data loss.
- (c) The Contractor shall ensure complete compatibility of all interfacing equipment. Any translators required to ensure the complete compatibility of the interface shall be provided.
- (d) The Contractor shall provide detailed calculations on the sizing of all the system's hardware and network equipment.
- (e) The NVR system in ITPMS room at VB1 and in Computer room at VBD shall allow the user to simultaneously view and record video streams from KPE/MCE cameras for 24 hours a day, 7 days a week continuously.
- (f) The NVR system shall cater to the viewing and recording of video streams for all the cameras in KPE/MCE with 100% spare capacity. The NVR system shall be scalable and expandable to cope with future increase in the number of cameras.
- (g) The NVR system shall have the capability to record, store and view video streams of all CCTV and AID cameras for a minimum storage retention period of 24 hours a day, 7 days a week for duration of one (1) month without the need to feed in any external storage media to store the recording output. The video streams captured shall be stored centrally within the NVR system's archive storage space and shall be overridden automatically after one (1) month storage retention period.
- (h) The NVR system shall enable the user to record each video streams at a minimum frame rate of 25 ips. The frame capture speed setting shall be configurable for all incoming video streams. The Contractor shall propose the maximum ips the NVR system can support.
- (i) The NVR system shall record images at the minimum resolution of 1920 x 1080 pixels.
- (j) The Contractor shall ensure that the NVR system have the hardware processing power, memory and network resources to handle a load of at least ten (10) concurrent users accessing the system for recorded video with the response time of 1 minute.
- (k) The system shall provide On-Screen Display (OSD) of recorded video streams and allow the user to view the recorded video streams with details, but not limited to the following:
 - (i) Date of video stream capture;
 - (ii) Time of video stream capture;

- (iii) Camera ID; and
 - (iv) Location.
- (l) The NVR system shall allow the user to perform real-time capturing and storage of snapshots of live video streams on ad-hoc basis while recording and viewing. The captured date, time Camera ID and location shall also be recorded.
- (m) The NVR system shall allow instant playback of recorded video streams while recording live. The instant playback of the recorded video streams shall not have a delay of more than one (1) second in comparison with the live stream. The Contractor shall provide tools and facilities to measure the delay and verify compliance with the specified system requirements.
- (n) The NVR system shall allow the user to name and insert book marking at the beginning and the end of any video streams.
- (o) The NVR system shall allow the user to search and retrieve the video streams with multiple filtering criteria including, but not limited to the following:
 - (i) Date of video stream capture (specific and range);
 - (ii) Time of video stream capture (specific and range);
 - (iii) Camera ID; and
 - (iv) Location.
- (p) The NVR system shall allow the user to archive all recorded video streams into a separate storage space within the system or into Digital Video Disc (DVD) for viewing or external devices for viewing.
- (q) The format of the extracted video shall be selectable by the user and shall be in open standard format. The video shall be able to be viewed on all PCs without the need to install proprietary player software.
- (r) The NVR system shall be configurable through user-friendly Off-the-shelf GUI to display minimum four (4) screen captures on the monitor at any one time.
- (s) The Contractor shall provide facilities in the system for archiving/exporting any stored video streams into external media, e.g. portable hard disk, thumb drive, etc.
- (t) The NVR system shall include media and video-spanning capabilities for archiving of the video streams into external media.

- (u) The Contractor shall propose and provide the functions, but not limited to the following:
 - (i) Archiving of video streams to external media;
 - (ii) Backup of all data and system application with a proposed backup strategy;
 - (iii) Security controls (e.g. user login profiles and passwords);
 - (iv) Performing housekeeping;
 - (v) System configuration including the addition and removal of cameras for recording;
 - (vi) Maintenance of system logs including authorised access users log and system configuration log;
 - (vii) Ability to do audit trail (e.g. date, time of exporting and deleting of video streams and user login profiles); and
 - (viii) Performing quick system failure recovery and reboot procedure.
- (v) The Contractor shall work with the Employer to determine and develop the administration, operation, maintenance and configuration functions for the NVR system.
- (w) The NVR system shall have a time synchronisation function to ensure that its clock time is synchronised with NTP master clock. This synchronising fix shall be performed at regular time intervals and during NVR system start-up.
- (x) The NVR system shall allow the ITPMS to ping and monitor their health status periodically.
- (y) All proposed products, tools and methodology shall be proven and widely used in the industry. The Contractor shall provide a list of site references that have adopted similar solutions, or technologies.
- (z) The NVR system shall be based on open standards and able to facilitate ease of upgrade to latest proven releases and technologies with minimal impact to daily operations.
- (aa) The Contractor shall make provisions in the NVR system infrastructure design such that any hardware, software or data changes required to bring future expansion shall be accomplished without service disruption to the NVR system.
- (bb) The design of the NVR system shall be modular and shall permit easy expansion to meet future requirements by the addition of further modules. Enhancements and alterations, if required,

shall be easy to introduce and the construction of programmes shall not affect the performance of the system. The software shall be designed with the capability for customisation and expansion.

5.3.5 KPE/MCE CCTV System Interface with CCTV System at Remote Location 1

- 5.3.5.1 The Contractor shall design, supply, deliver, install, configure, test and commission KPE/MCE CCTV system for the connection with the CCTV System at Remote Location 1 to transmit and receive video and data, as depicted in figure 5.3.5-1. The Contractor shall provide the Nationwide Broadband Network (NBN) link between MCE VB1 and Remote Location 1. The Contractor shall pay for all application fees and recurrent costs up till the end of Defects Liability Period (DLP).

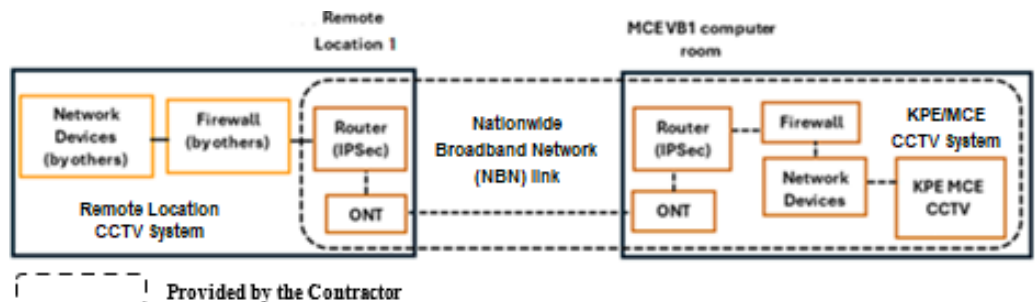


Figure 5.3.5-1 Connection MCE VB1 and Remote Location 1

- 5.3.5.2 The NBN link between MCE VB1 and Remote Location 1 shall cater for 120 concurrent videos.
- 5.3.5.3 The Contractor shall provide the required works, fibre optic cables, switches and all the additional equipment and accessories required up to the CCTV system's network at Remote Location 1.
- 5.3.5.4 The Contractor shall provide all the interface design and tests information to the CCTV system contractor at Remote Location 1 and Superintending Officer (SO) for acceptance.
- 5.3.5.5 All interface details between KPE/MCE CCTV system and the CCTV system in Remote Location 1 shall be discussed and commonly agreed upon by the Contractor and the CCTV system contractor at Remote Location 1. A joint statement shall be signed by both parties in the Final Interface Control Document and submit for SO's acceptance.
- 5.3.5.6 The CCTV system contractor at Remote Location 1 will take the lead in planning and coordinating the execution of the interface design and

integrated tests with the Contractor including, but not limited to communication protocol tests, pre-tests, detailed point-to-point tests, Integrated system functional tests and CCTV system failover tests with the KPE/MCE CCTV system connecting to Remote Location 1.

- 5.3.5.7 The CCTV system contractor at Remote Location 1 will be responsible for the preparation of test procedures.
- 5.3.5.8 The CCTV system contractor at Remote Location 1 will be responsible for the preparation and maintenance of time schedules covering the test activities plus subsequent re-testing, maintenance of a fault log of outstanding items that require re-testing and liaison with Contractor.
- 5.3.5.9 The CCTV system contractor at Remote Location 1 will co-ordinate with the relevant staff and resources as required for the execution of the tests and recording and reporting of all test results.
- 5.3.6 Web Cameras (Webcam)
 - 5.3.6.1 Webcam shall be fixed FHD PoE cameras and shall be installed at locations identified by Superintending Officer (SO).
 - 5.3.6.2 Webcam shall be colour camera and shall be used for acquisition of traffic conditions. Webcam shall be housed in IP66 camera enclosures and shall be mounted on lamp pole.
 - 5.3.6.3 The CCTV system shall provide a snapshot bitmap of the current view of each web camera to the webcam server provided by ITPMS upon request. The bitmap images shall be captured at a minimum resolution i.e. 1920 x 1080 pixels. The bitmap images from the CCTV system for each web camera input at regular one (1) minute intervals.
 - 5.3.6.4 The Contractor shall liaise, interface and coordinate with the interfacing contractors, to determine the interface requirements.
 - 5.3.6.5 Each new Power over Ethernet (PoE) switch shall connect up to maximum of four (4) cameras with minimum 30% spare ports.
- 5.4 Traffic Barrier System
 - 5.4.1 The Traffic Barrier System shall comprise the following:
 - (a) Entrance Ramp Barriers; and
 - (b) Traffic Signals.
 - 5.4.2 Entrance Ramp Barriers

- 5.4.2.1 A single and a pair of Entrance Ramp Barriers (ERB) shall be installed at each commencement of ramps leading to the KPE/MCE tunnels. Single ERB are to be installed at slip roads V, S and 9. A pair of ERB are to be installed at slip roads A, D, F, G, Q, M, P, W2, 5, 4a, 4b and 8. ERS are used in conjunction with traffic signals. Longer barrier arms i.e. 8.5m shall be installed for the wider slip roads. e.g. MC04 entry from ECP (City).
- 5.4.2.2 The equipment required for the Entrance Ramp Barriers shall include the following, but not limited to:
- (a) Barrier Housings;
 - (b) Barrier Motor Drive Unit;
 - (c) Barrier Arms;
 - (d) Barrier Controller Unit;
 - (e) Barrier LEDs Strips Warning Lights;
 - (f) Barrier Audio Siren; and
 - (g) Barrier Electrical Components.
- 5.4.2.3 The Contractor shall design and provide the single or a pair of barrier arms to cover all the traffic lanes including road shoulder. For the pair of barriers, the gap between the two barrier arms shall not exceed 0.2 metres, subject to site conditions and shall be finalised during the design phase.
- 5.4.2.4 Each ERB shall be a standard manufactured item of a field proven design. Each ERB shall have weatherproof housing and operating mechanisms and shall include controls and accessories.
- 5.4.2.5 The operation of the ERB shall be capable of being remotely monitored and controlled by the OCC operators via PMCS by KPE-MCE ITPMS 1.0. The Contractor shall migrate these interfaces to KPE-MCE ITPMS 2.0 at a later stage to allow the OCC operators to centrally control and monitor the ERB. Provision shall also be made for a common local control panel to be installed near ERB to control the ERB and TFS at the site.
- 5.4.2.6 During any closure operation, prior to the closure of entrance ramp, the ERB shall check that the associated TFS is exhibiting the appropriate closure indication and the LEDs strips warning lights and audible siren are in operation.

- 5.4.2.7 For re-opening of the tunnel, after confirmation that barrier is open, the operator will change the associated TFS from red indication to either amber or green, before going to blank indication.
- 5.4.2.8 The barrier housings shall be minimum IP54 (Housing A) and IP66 (Housing B) rated as depicted in figure (as shown below). Housing A shall be corrosion-resistant, dust-tight and weather-tight enclosure. The housing shall be rigidly constructed, free of warps and buckles and shall form an integral part of the unit. The housing and frame shall be designed to prevent distortion of the housing in the event of collision with the barrier arm. Large gasket access doors shall be included which allows servicing the barrier from either side. Proper and aesthetically pleasant housings shall be provided to protect the barriers from vandalism.

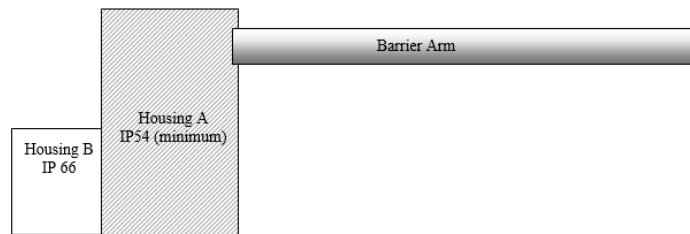


Figure 5.4.2.8-1 Barrier Housing

- 5.4.2.9 Housing A shall be used to house the controller, transmissions, barrier arm attachment, etc. and Housing B shall be used to house the barrier local control panel, circuit boards, etc.
- 5.4.2.10 Each barrier shall be able to operate locally at site using push button for open operation, push button for close operation, key switch for local/remote operation and switch to mute the audible siren. The push buttons and switches are to be housed in IP66 enclosure (Housing B). The push buttons and switches shall be common for a pair of barriers. The key switch for local/remote operation shall be common for TFS and ERB. Housing B in figure 5.4.2.8-1 shall also house the TFS local manual control.
- 5.4.2.11 The transmissions shall be a fully enclosed and direct drive unit. The drive unit shall not use belts or chains.
- 5.4.2.12 The Contractor shall provide new foundations, underground cable pipes, cables, cable support system, trenching works, back layering works, etc. required for the Works.

- 5.4.2.13 The Contractor shall engage qualified Professional Engineer (civil) to design and endorse the foundations for the ERB including the construction method for the new foundations.
- 5.4.2.14 The Contractor shall be responsible to perform the following works when reusing existing cables and cable support system for the ERB:
- (a) Check the quality, integrity and suitability of the existing cables; and
 - (b) Ensure that the existing cables are suitable for the ERB and able to meet the system performance as specified in the TS.
- 5.4.2.15 The Contractor shall provide and lay new cables including cable supporting system. The Contractor shall provide and lay new cables from the ERB field equipment to the tunnel niches.
- 5.4.2.16 The barrier arms shall be fabricated from aluminium. Waterproof and weatherproof protective rubber strip shall be provided on the underside of each barrier arm. The actual height of the arm from the ground, shall be subjected to site conditions and shall be finalised during the design phase.
- 5.4.2.17 Both the barrier housing and barrier arm shall be designed and manufactured from the same manufacturer. The system shall with proven track record of performance, reliability and proven to work and function in a road tunnel environment similar to KPE/MCE, subject to the SO's acceptance.
- 5.4.2.18 The height from the base of the barrier arm to the road surface during closed position shall be proposed by the Contractor and submitted for the SO's acceptance.
- 5.4.2.19 The face of the barrier arm shall be provided with illuminated LEDs strip and 45 degree diagonal red and white stripes of 400mm in width. The stripes shall be reflective sheeting and shall be of approved high intensity material.
- 5.4.2.20 All the barriers shall be operable remotely from OCCs. A local control switch shall be also available at the barrier to enable local control and operation of the barriers.
- 5.4.2.21 A hand tool of manual mechanical backup system shall be included with each barrier to operate the barrier during power failure and for failure of remote mechanical backup system. An automatic safety disconnect shall

also be included to disconnect the control circuit while using the hand tool.

- 5.4.2.22 The main shaft shall be rigidly attached to the main frame with heavy bearings on each end, preventing any strain of the panel or arm assembly being transmitted to the drive unit. The rotating main shaft shall not be less than 65mm in diameter and shall be journalled in radial and thrust bearings.
- 5.4.2.23 Arms shall be mounted to the barrier main shaft. Panel and arm lengths are measured from the centreline of the barrier main shaft to the tip of the arm, unless otherwise specified.
- 5.4.2.24 The red in colour LEDs strips warning lights shall be mounted and installed on the face of each barrier arm. The Contractor shall submit material and installation details of the LEDs strips warning lights for the acceptance of the SO.
- 5.4.2.25 The LEDs strips warning lights shall start to flash when the barrier arm started to move from open to close position. The LEDs strips warning lights shall remain flashing continuously when the barrier is in close position. The LEDs strips warning lights shall only be de-energised and stop flashing when the barrier is in fully open position. The LEDs strips warning lights shall be rated to IP54 or better.
- 5.4.2.26 The brightness of the LEDs strips warning lights shall be able to provide ample visibility to the motorist any time of the day and subject to the acceptance of the SO.
- 5.4.2.27 Each barrier shall be provided with an audible siren which shall be energized and produce a warning sound when the barrier starts its movement from open to closed position and vice versa. The audible siren will be de-energized when the barrier is fully closed or fully opened. It shall be possible to on and off the audible siren at Housing B. A local switch shall also be installed at the Housing B to de-energize the audible siren.
- 5.4.2.28 The ERB shall have a local interlock with the TFS such that ERB is allowed to close only when the TFS has been set to red. However, in the event of TFS equipment fault or power failure, it shall still be possible to operate the ERB from Housing A manually.
- 5.4.2.29 The audible siren shall have a sound level ranging from 45 dB (A) to 90 dB (A) and it shall be provided with a volume control.

- 5.4.2.30 Barrier operation shall be smooth with gradual acceleration to approximately 50 percent of arm travel then gradual deceleration until the “step” position is reached. The operating time for a complete 90-degree rotation of arm, either opening or closing, shall be 7 seconds maximum.
- 5.4.2.31 The Contractor shall submit detailed and accurate shop drawings and design calculations for the ERB to the SO for acceptance.
- 5.4.2.32 The Contractor shall propose the means of signal transmission between control centres and barriers and submit for SO's acceptance. The response from the time the operator in the OCCs initiate a command to the time the barriers start to move shall not be more than three (3) seconds.
- 5.4.2.33 There shall be self-diagnostic features to check the status of the barrier system to alert the OCC operator of any faults through alarms sent back to the control centres.
- 5.4.2.34 All wiring within the barriers shall be routed in properly against lightning or over-voltage conditions with appropriate lightning and surge protectors.
- 5.4.2.35 In case of power failure, power restoration to the barriers or faulty barrier controller, the barriers shall remain in its last known state.
- 5.4.2.36 The design of the ERB including the controller and other equipment shall also ensure no unintended operation of the barrier due to the following, but not limited to:
- (a) Power loss;
 - (b) Controller failure;
 - (c) Poor weather condition (Lightning);
 - (d) Electromagnetic Compatibility (EMC);
 - (e) Power surge; and
 - (f) Short circuits.
- 5.4.2.37 The Contractor shall design and provide a local interlock between ERB and TFS to ensure no unintended operation of the barrier. The TFS local manual control shall interlock with the ERB local controller for the safe operation of barrier. The design of local interlock shall be submitted to the SO for acceptance.
- 5.4.3 Traffic Signals

5.4.3.1 A single and a pair of Traffic Signals (TFS) shall be installed at the commencement of ramps leading to the KPE/MCE tunnels. A single TFS shall be installed at slip roads A, D, F, G, Q, V, M, P, S, W2 and 9. A pair of TFS shall be installed at slip roads 5, 4a, 4b and 8. These newly installed TFS shall replace the existing TFS at the above locations. The TFS are used in conjunction with entrance ramp barriers.

5.4.3.2 The TFS shall consist of minimum 200mm diameter signal heads showing the following aspects:

Aspect	Function
Steady Red	All traffic Stop
Steady Amber	Prepare to Stop
Steady Green	Proceed (re-opening of road)
Flashing Amber	Warning
Blank	Default Condition

5.4.3.3 The TFS shall be remotely controlled by the KPE-MCE ITPMS 1.0. The Contractor shall migrate these interfaces to KPE-MCE ITPMS 2.0 at a later stage to allow the OCC operators to centrally control and monitor the TFS. Local manual control with push buttons housed in IP66 enclosure shall be provided by the Contractor to allow for urgent operation and maintenance. Individual push button, for switch on and switch off, shall be provided for each aspect as specified in Clause 5.4.3.2. Housing B in figure 5.4.2.8-1 shall also house the ERB local manual control.

5.4.3.4 For a pair of TFS, the control shall operate a pair of signal heads which controls an individual traffic 'stop-line'. It shall not be possible for signals controlling the same 'stop-line' to display different aspects.

5.4.3.5 The TFS local controller shall have the capability of detecting the on and off states of the display elements and display failures. Failures shall be classified as major when:

- (a) More than 8% of all pixels fail;
- (b) Communications failure;
- (c) Failure to complete a control command;
- (d) Controller malfunction;
- (e) High temperature; and
- (f) Traffic Light Optical Assembly (OA) fault. The individual traffic light (Red, Amber, Green) OA fault status shall be able to be monitored.

- 5.4.3.6 All failures and status shall be reported to KPE-MCE ITPMS 1.0. The Contractor shall migrate these interfaces to KPE-MCE ITPMS 2.0 at a later stage to allow the OCC operators to centrally control and monitor the TFS.
- 5.4.3.7 Aspect Housing
- (a) The Contractor shall supply and install aspect housings with alloy/galvanised brackets, gaskets and fitted with the LED Optical Assembly (OA) to signal poles. All aspect housing ends shall be properly and firmly covered with approved polycarbonate caps using bolts and nuts. Stainless steel screws shall be provided for fixing the aspect housing to the pole. Aspect hoods shall be properly and firmly secured with stainless steel screws.
 - (b) The layout of the aspects in the signal head shall comply with LTA's Standard for Design of Traffic Signals and Road Traffic Act for Traffic Signal. The arrangement to be used is:
 - (i) Ground signal heads – minimum 200mm Red, Amber and Green (top to bottom); and
 - (ii) Ground signal poles.
- 5.4.3.8 The Contractor shall supply and install hot-dipped galvanised iron ground poles with armoured glands. Signal cables shall be earthed to ground at the signal poles using armoured glands and earth-tags.
- 5.4.3.9 The Contractor shall provide new foundations, underground cable pipes, cables, cable support system, signal poles, trenching works, back layering works, etc. required for the Works.
- 5.4.3.10 The Contractor shall engage qualified Professional Engineer (civil) to design and endorse the foundations for the TFS including the construction method for the new foundations.
- 5.4.3.11 The signal poles shall be manufactured from hot-dipped galvanised iron pipe with manufactured date engraved onto the pole label. The tensile strength of the steel shall be 3800 kg/cm². Unnecessary opening shall not be allowed on the signal poles.
- 5.4.3.12 Mass concrete (Grade 35) pre-cast foundations shall be used to support the poles. The poles shall be fixed to the foundation by bolting on to a base plate. For ground poles, the GI base plate shall not require 10mm thick GI plate stiffener. The Contractor shall provide the pre-cast foundations and shall engage qualified Professional Engineer (civil) to

design and endorse the size of the pre-cast foundations for the TFS including the construction method of these pre-cast foundations.

- 5.4.3.13 The surface of the ground signals pole from the foundation to a level of 300mm above the ground level shall be cleaned and coated with a layer of approved high build black epoxy paint. A coating of a minimum dry film of 60microns thick (both internal and external) shall be applied. Coating shall be done with a first layer of primer and two (2) coats of black epoxy paints (factory painted).
- 5.4.3.14 No mortar or concrete haunching for the base of the pole is required. All poles shall be planted one (1) metre away from the kerb.
- 5.4.3.15 One coat of primer and two finishing coats of paint shall be applied to all exposed surfaces. In addition, a layer of black epoxy paint shall be applied 300mm from the base of the pole.
- 5.4.3.16 Method statement on the pole installation process shall be submitted to the SO for acceptance.
- 5.4.3.17 LED Optical Assembly
 - (a) Optical Assembly (OA)
 - (i) The optical assembly shall consist of a transparent, waterproof protective front cover with an IP65 back housing to shield the PCB and other components mounted on it from moisture and dust, and the necessary waterproof wiring connectors and terminals. The parabolic reflector used in the optical assembly shall be one piece.
 - (ii) The optical assembly shall be a sealed unit to lock out dust, dirt and moisture from the LED array, without the help of the traffic light housing, to prevent degradation of the optical-grade epoxy encapsulating material due to the absorption of moisture.
 - (b) Diffusion Lens
 - (i) The lens shall be made of several bi-convex prisms arranged such that when in use, the optical assembly will refract the monochromatic light from the LED array to form a radiation pattern.
 - (ii) The lens shall be made of acrylic material designed with proper mount and with ample mechanical strength to withstand any possible mechanical stress during installation and maintenance cleaning without undue deformation.

(c) Transparent and Waterproof Protective Front Cover

The purpose of the cover is to protect the LED arrays from the hot and humid environment. It shall mate with the protective back housing to form a waterproof optical assembly. It shall be made of acrylic material having the following characteristics:

- (i) Corrosion-resistant.
- (ii) Ample mechanical strength to withstand any possible mechanical stress during installation and maintenance without undue deformation.
- (iii) All parts shall be clean, smooth and free from flaws, cracks and other imperfections.

(d) IP65 Back Housing

The purpose of the back housing is to form a waterproof optical assembly when mated with the front cover. It shall be made of suitable material that can be mated with the front cover. The back housing shall have the following characteristics:

- (i) Corrosion-Resistant.
- (ii) Ample mechanical strength to withstand any possible mechanical stress during installation and maintenance without undue deformation.
- (iii) All parts shall be clean, smooth and free from flaws, cracks and other imperfections.
- (iv) A proper gasket shall be used so that the complete assembly is waterproof and dustproof.

(e) Waterproof and Weatherproof Gasket

- (i) The waterproof/weatherproof gasket shall be manufactured using high quality material, which can resist the hot and humid weather of Singapore and shall be anti-fungus so that it shall not shrink, crack or deteriorate with time.
- (ii) The Gasket shall:
 - (I) Prevent water, dust and dirt from entering the traffic signal housing.
 - (II) Act as an adapter so that the 'one-design-fits-all' concept can be applied.

(f) Light Emitting Diodes (LED) Array

- (i) Construction
 - (I) The LED shall be constructed in such a way that the layered semi-conducting die mounted on a conducting lead with a bond wire connecting the top of the die to the other conducting lead is encapsulated in an optical-grade epoxy with UV inhibitor so as to protect it from the sun and moisture, it prevents oxidation and degradation to the material. Any aluminium and/or mirrored surface used to increase the luminous intensity shall be internal to the die and encapsulated in the optical-grade epoxy to prevent oxidation.
 - (II) In addition, the LED shall maintain its intensity level above 60 percent for no less than 7 years under continuous exposure under the hot and humid Singapore weather condition and operating at their normal operating current. The degradation shall be gradual.
- (ii) Viewing Angle
 - (I) The LED shall be untinted and non-diffused, generating spatial radiation patterns at 30 degree viewing cone angles.
- (g) LED Luminous Intensity
 - (i) The Contractor shall ensure that the luminous intensity of the LED is clearly viewable by the motorists at different times of the day at all installed locations.
- (h) OA Design Features
 - (i) Random distribution of the LED connected in series. The gang of LED (LED that are connected in series) shall be distributed as randomly as possible so that when one or more LED fail in any one or more gangs, the resultant traffic aspect will not show any sign which will mislead the road users in any way.
 - (ii) Maximum number of series-connected LED. The maximum number of LED which is connected in series shall not exceed 4.
- (i) Design Philosophy
 - (i) Ease of Maintenance.

- (I) The design of the system shall facilitate easy in preventive maintenance, change of units and repair. Hardware fault clearance of the equipment shall be by means of plug-in units.
 - (II) As a fundamental necessity, it shall be possible to carry out maintenance work with no degradation of the functions and without any safety hazard to the maintenance personnel.
 - (III) It shall be possible for LED traffic signals, which are found to be faulty, to be taken off-line for trouble-shooting and repair without the need to power off the whole or part of the system.
 - (IV) Any faulty aspect shall be replaced with a full working LED traffic signal unit to ensure the continuous display of traffic light status without performance degradation.
- 5.4.3.18 TFS shall have local electrical interlock with adjacent barriers to safeguard against accidental barrier activation due to Electro-Magnetic Interference (EMI), lightning or other factors.
- 5.4.3.19 Each TFS unit shall be of LED type and have three (3) aspects: red, amber and green. The control and monitoring circuitry shall be designed for four (4) switching states of Red, Amber, Green and Blank. Other combinations of display shall not be possible.
- 5.4.3.20 The sequencing of TFS shall strictly follow the standard as specified in Clause 5.4.3.7 (b). When signals are turned on, they shall give a display which is consistent with the basic interlocking matrix as it relates to other signs and signals in the vicinity.
- 5.4.3.21 The colour arrangement shall comply with standard as specified in Clause 5.4.3.7 (b). Each signal head assembly shall be provided with a backing board. A suitable visor shall be fitted to each of the optical systems. The materials of the visors shall be resilient and shall return to shape after impact but shall be sufficiently rigid to withstand distortion under all weather conditions.
- 5.4.3.22 Full technical details together with details of the mounting arrangements endorsed by qualified Professional Engineer (PE) shall be submitted to the SO for acceptance.
- 5.4.3.23 The Contractor shall submit a sample signal head complete with optics, electrical equipment, mounting brackets, visors and backing board during the design phase for evaluation and acceptance by the SO.

- 5.4.3.24 The Contractor shall provide and lay new cables including cable supporting system from the TFS field equipment to the tunnel niches. The Contractor shall provide underground cable pipes, trenching works, back layering works, etc., for new cablings between the TFS and KPE/MCE PMCS.
- 5.4.3.25 The Contractor shall perform configuration and programming works at the existing Programmable Logic Controllers (PLC) at the Ventilation Buildings (VB) and at the existing and new Remote Input/outputs (RIO)/ Network RIO in the KPE/MCE tunnels, to include the TFS I/O points for monitoring and control via PMCS by KPE-MCE ITPMS 1.0. The Contractor shall migrate these interfaces to KPE-MCE ITPMS 2.0 at a later stage to allow the OCC operators to centrally control and monitor these I/O points.

6 Plant Monitoring and Control System

6.1 General

- 6.1.1 The Contractor shall be responsible for the scope of work and requirements for the Plant Monitoring and Control System (PMCS) in KPE/MCE as described in this section.
- 6.1.2 The Contractor shall liaise and coordinate with ITPMS and Employer's appointed contractors to fulfil all interface during the design interface period.
- 6.1.3 The PMCS shall interface with the KPE-MCE ITPMS 1.0. The Contractor shall migrate these interfaces to KPE-MCE ITPMS 2.0 at a later stage to allow the OCC operators to centrally control and monitor the M&E services and E&M systems.
- 6.1.4 The PMCS shall not be 'locked' due to a failure. Additionally, command and control operation shall have a priority over other system activities.
- 6.1.5 The Contractor shall design, supply, delivery, installation, implementation, migration, testing, commissioning, decommissioning, provide maintenance during Defects Liability Period (DLP), documentation, training and any other necessary works for completion of the PMCS.
- 6.1.6 The Contractor shall design, supply and install new modules to replace the followings existing Remote Input/outputs (RIO) and Profibus Input and Output Slave (PIOS) in KPE, but not limited to:
 - (a) RIO 01 to RIO 12

- (i) 31 nos. Profibus modules.
 - (b) RIO 11 and RIO 12
 - (i) 2 nos. CPU modules.
 - (ii) 2 nos. Ethernet modules.
 - (c) All PIOS
- 6.1.7 The Contractor shall submit an alternative proposal to replace entire RIO and PIOS in KPE as specified in Clause 6.1.6, with NRIO.
- 6.1.8 The new RIO and PIOS to be provided and installed under this Contract shall be compatible with the existing PMCS Programmable Logic Controllers (PLC) in KPE VBs.
- 6.1.9 The Contractor shall perform configuration and programming works for the following equipment at these locations, but not limited to the following:
- (a) Configuration and programming works for PLCs in all VBs for the additional and removal of I/O points in KPE and MCE;
 - (b) Configuration and programming works for new and existing RIOS and PIOSs for the additional and removal of I/O points in KPE; and
 - (c) Configuration and programming works for existing Network RIOS to include the additional I/O points in MCE.
- All I/O points shall interface to KPE-MCE ITPMS 1.0. The Contractor shall migrate these interfaces to KPE-MCE ITPMS 2.0 at a later stage.
- 6.1.10 The Contractor shall coordinate with Employer's appointed contractors for the existing PLC program in order to perform the configuration and programming works for KPE and MCE.
- 6.2 System Configuration
- 6.2.1 The Contractor shall engage PLC programmer to perform configuration and programming works on the PMCS PLCs, RIOS, PIOSs and NRIOs. All configuration and programming works by the Contractor shall be properly documented and submitted for acceptance by the SO.
- 6.2.2 The control system hardware and software components provided by the Contractor shall be able to perform the assigned functions and seamlessly integrate with existing PMCS components.
- 6.2.3 The Contractor shall be responsible for the supply, installation and testing of all the necessary cabling and accessories to deliver a complete

functional system. Any media converters by the Contractor's system design for conversion between optical signals and ethernet signals shall be provided under this Contract.

- 6.2.4 All necessary hardware and software shall be provided to ensure that the PMCS installation is complete, safe and ready for operation.
- 6.2.5 The Contractor shall take into account factors such as ease & economy of maintenance when providing the hardware and software for RIO and PIOS. In this regard the equipment and software conforming to open standard or common industrial standard are preferred.
- 6.2.6 Equipment shall be supplied by manufacturers who have manufactured similar control system equipment for a period of at least five (5) years.
- 6.2.7 All equipment and material of the same type and performing the same function shall be of the same make and model, in order to allow interchangeability and minimise stock of spare parts.
- 6.2.8 The Contractor shall ensure that the effect of the failure of RIO and PIOS shall not affect the normal operation of other PMCS components.
- 6.2.9 Terminal strips and terminals shall be clearly and indelibly coded. Terminals carrying mains electrical power shall be segregated from other terminals with protection cover and warning labels.
- 6.2.10 All wiring and cabling shall be neat, firmly connected, adequately supported to prevent vibration and so arranged to prevent strain on individual wires.

6.3 PMCS Requirements

6.3.1 Remote I/O and PIOS

- (a) Remote I/O and PIOS in the tunnels shall be connected via existing PMCS PLCs in the ventilation buildings to the ITPMS Front-end Logical Servers (FELS) provided by others. This allows data concentration and subsequent information exchange between PMCS and ITPMS via existing network.
- (b) Remote I/O and PIOS shall be installed at ITPMS niches in KPE tunnels.

6.3.2 System Capacity

- (a) The system shall be designed with a capability for future expansion. The Contractor shall demonstrate to the satisfaction

of the Superintending Officer (SO) that the system and equipment provided possess sufficient spare capacity in terms of processing power, memory, ports, and bulk data storage, to allow for this future expansion.

6.3.3 Operation and Maintenance

- (a) All the components provided shall be of module-type to ease the maintenance of the system.
- (b) All equipment shall be designed and manufactured to facilitate inspection, cleaning, maintenance and repair. Particular attention shall be paid to the life expectancy and maintenance requirements of equipment in locations with restricted and difficult access.

6.3.4 Plant Control Equipment

- (a) The CPU, memory, Input/Output, power supply and other communication modules shall be hot-swappable.
- (b) Each module shall perform self-diagnostics in the background and any hardware failure detected shall be reported to ITPMS.
- (c) Each circuit card shall have sufficient visual indications for I/O status and system status to give clear indications of all on-line activities. This shall include LEDs for transmit, receive signal, power available, power on, each digital status input and output, and fault.
- (d) Extensive facilities for diagnostic and interrogation shall be provided to access I/O logic, communication interrogation and control via maintenance laptop.
- (e) Each plant control equipment shall offer spare slots for additional modules to achieve 30% spare design capacity.
- (f) The I/O Modules for digital input/output points and analogue I/O points shall have 30% spare input/output points for future use.
- (g) Logic Programming
 - (i) The PLC languages used in KPE and MCE PLCs is ladder logic, structured text, function block diagram and sequential function chart editors for programme development.

6.3.5 Equipment Performance

6.3.5.1 PMCS Equipment Performance

- (a) Under no circumstances shall any part of the PMCS become locked due to the failure or non-operation of a selected point or "Execute" command.

6.3.5.2 Failure Monitoring and Recovery

- (a) The existing PLC shall be to detect any hardware failure and software hang-up/fault causes by the PIOS, RIO and software installed by the Contractor. This shall also include the mutual monitoring that checked for fault and failure. All alarms, faults and failure shall also be sent to ITPMS.
- (b) Any internal data link or external interface link failure shall raise an alarm to existing PLC and subsequently to ITPMS.

6.3.5.3 The Contractor shall demonstrate quantifiably the performance of the networks provided as stated in the following:

- (a) Response Requirements
 - (i) The time taken from the completion of any command sequence to the resultant outputs appearing at the appropriate interface to the system, shall be appropriate for a real time system operation of not greater than 100ms maximum.
- (b) Fault Tolerance
 - (i) No single point of failure shall affect the data traffic transaction capability of the entire network.

6.3.5.4 Hardware and Software Requirements

- (a) Design Considerations
 - (i) The Contractor shall supply hardware with sufficient memory and processing power for running the application software .
 - (ii) The supplied hardware shall use suitable modular design method to enable the hardware to be easily replaced or upgraded to cope with additional processing capacity, memory, communication links/ports and I/O capacity.
 - (iii) The replacement of hardware shall not cause any degradation of the performance of the system.

- (iv) The modification of software shall not cause any degradation of the performance of the system.
- (b) Resource Spare Capacity
 - (i) The Contractor shall provide hardware platforms allowing for spare capacity of minimum 30%.
 - (ii) These spare capacity requirements shall apply to the following resources:
 - (I) Memory, consisting of all memory used for run-time processing and storage of data;
 - (II) Communication links/ports, consisting of the ports available for network connections and port to port connection; and
 - (III) I/O capacity, this associated with equipment I/O points and software points. It defines the amount and type of spare I/O points provision in PMCS that can be connected and processed.
 - (iii) The usage and allocation of the spare capacity shall be subject to acceptance of the SO.
 - (iv) The spare provisions for I/O points shall be configured and wired to the terminal blocks in the I/O enclosure. This shall be tested and ready for use.

6.4 Control and Monitoring I/O points

6.4.1 RIO and PIOS in KPE shall perform control and monitoring functions for various systems and equipment, but not limited to the following:

- (a) Entrance Ramp Barrier;
- (b) Doors (Escape Staircase Door Ground, Escape Staircase Door Tunnel; Emergency Cross Passage Door, Vehicular Cross-Over Door, Emergency Niche Door, Fire Extinguisher Door);
- (c) Fire Extinguisher Contact Switch;
- (d) Strobe Light;
- (e) Drainage system (Storm Water Control Panel, Storm Water Pump, Waste Water Control Panel, Waste Water Pump);
- (f) Bi-Directional Amplifier (Tetra and Tetrapol);
- (g) Uni-Directional Amplifier (FM); and
- (h) Traffic Signal.

- 6.4.2 The Contractor shall refer to **TS Appendix A-5** for the PMCS I/O points in KPE on the Traffic Signals and refer to **TS Appendix A-6** for the PMCS existing control and monitoring I/O points in KPE.
- 6.4.3 The NRIO in MCE shall perform control and monitoring functions for ERB and TFS, but not limited to the following:
- (a) Entrance Ramp Barrier; and
 - (b) Traffic Signal.
- 6.4.4 The Contractor shall refer to **TS Appendix A-5** for the PMCS I/O points in KPE on the Entrance Ramp Barrier and Traffic Signals.

7 Video Wall System

- 7.1 The Contractor's scope of works for the video wall system at OCC at VB1 and SOCC at VBD shall include design, supply, deliver, install, configure, test and commission full-colour indoor high-resolution Light-Emitting Diode (LED) video wall based on the latest technology, inclusive of the necessary electrical power supply, mounting accessories, necessary devices, cablings and perform modification works such as civil works e.g. hacking, openings, replacement of acoustic panels, etc. to the feature wall.
- 7.2 The Contractor shall propose, supply and install indoor full colour LED video wall within an approximate maximum dimension of 14m (L) X 2.1m (H) for OCC in VB1 and 11m (L) X 2.1m (H) for SOCC in VBD. The LED video wall shall be arranged in a concaved curved display configuration.
- 7.3 The proposed video wall system at OCC and SOCC shall be able to operate 24 hours a day, seven days a week.
- 7.4 The proposed indoor full colour LED video wall shall minimally be able to support, but not limited to the following requirements:
- (a) Support HDMI/DVI composite video input interfaces;
 - (b) Display minimum twenty-four (24) input sources;
 - (c) Configurable pre-set layout with a minimum display of up to six (6) sectors;
 - (d) Chip On-board (COB) technology;
 - (e) Bezel to bezel gap of 0mm with 1.2mm pixel pitch;
 - (f) Viewing angle of 160 degree by 140 degree;
 - (g) Brightness higher than eight hundred (>800) nits (adjustable);

- (h) Brightness uniformity higher than ninety eight percent (>98%);
- (i) Dimming 0 to 100%;
- (j) Contrast >9000:1;
- (k) One hundred thousand (100,000) hours LED lifespan;
- (l) Power supply with redundancy; and
- (m) Control software.

- 7.5 The proposed LED video wall shall be proven for use in Control Centre environments, proven and using the latest technology in the market and the manufacturer shall have a technical support office located in Singapore. The proposed model shall be certified with safety, health, and environment standards such as CE and RoHS certification, and for effective quality management standards such as ISO 9001.
- 7.6 The Contractor shall propose the video wall configuration with considerations for the best viewing angle for the operators and shall be installed in a modular LED cabinet configuration, flushed with the feature wall and taken into consideration proper heat dissipation features to prolong the video wall lifespan.
- 7.7 The maintenance of the video wall shall be designed for front and rear access and the Contractor shall provide the necessary tools, equipment, maintenance platform and access door required to access and maintain the video wall without disturbing operations in the OCCs.
- 7.8 The Contractor shall supply and install the display panel frame and bracket which shall be made of steel construction or equivalent material subject to the SO's acceptance.
- 7.9 The Contractor shall provide new videowall mounting structure and perform modification works to the current openings and feature wall to suit the installation of the proposed LED video wall. The mounting structure design shall be based on functional requirements and shall provide for easy maintenance of video wall.
- 7.10 The Contractor shall be responsible for decommissioning, removing and perform a proper disposal of the existing structure and projectors of video wall at VBD and VB1.
- 7.11 The whole LED screen with structure and electrical design, including drawings and design calculations submitted by the Contractor shall be endorsed by qualified Professional Engineer (PE) before submission to the SO for acceptance.

- 7.12 The indoor full colour LED video wall shall be able to simultaneously display minimum twenty-four (24) inputs video sources in pre-set configuration layout and picture-in-picture display. The video and data sources to simultaneously display live video streaming of CCTV images, tunnel schematic (real-time sign message and display aspect), real-time traffic operational data (volume, occupancy and speed) graphs of the entire KPE/MCE, laptop plug in content, etc. The data sources shall be discussed and finalised during the design submission.
- 7.13 The Contractor shall be responsible to connect the data sources to the video wall. The Contractor shall be responsible to connect the video sources to the video wall and provision for the necessary accessories such as converters and receivers, to project the respective video sources to the video wall.
- 7.14 The video wall shall also be capable of displaying the CCTV videos throughout the mimic displays including the automatic video designated when an incident, accident or fire alarm occurs. These video displays shall also be moveable and resizable using the mouse.
- 7.15 The video wall system in OCC and SOCC provided by the Contractor shall be able to operate the display from ITPMS. The OCC operators shall be able to switch and select the displays required. The Contractor shall ensure that the switching of the displays and the time taken for the displays to be projected on the video wall shall not exceed one (1) minute.
- 7.16 The Contractor shall provide a minimum 10-inch colour touch panel device to control the multi-windows display on the video wall at each OCC and SOCC.
- 7.17 The Contractor shall supply and install the necessary accessories and equipment, that includes but not limited to video interface controller/matrix switcher and video processors, power supply modules, with full redundancy, to allow the projection and blending of the selected inputs to be displayed on the large screen and resiliency to system failures.
- 7.18 The Contractor shall be responsible for transportation of video wall system and associated furniture to the site for installation. Consideration shall be given to the fact that the corridors and doors have already been constructed prior to the time of transportation. This may introduce constraints on the size of components which can be brought into the Control Centre.

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- 7.19 The Contractor shall refer to **TS Appendix A-5** for the schedule for video wall system I/O points. All failures and status shall be reported to ITPMS.